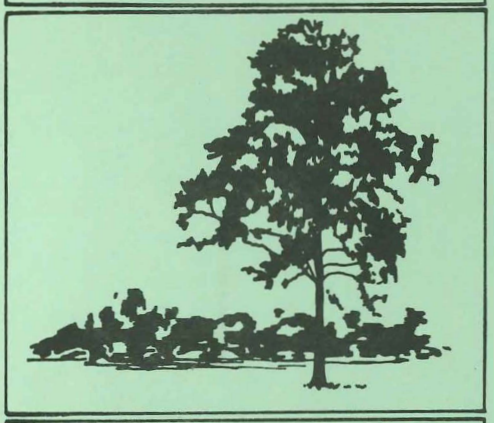

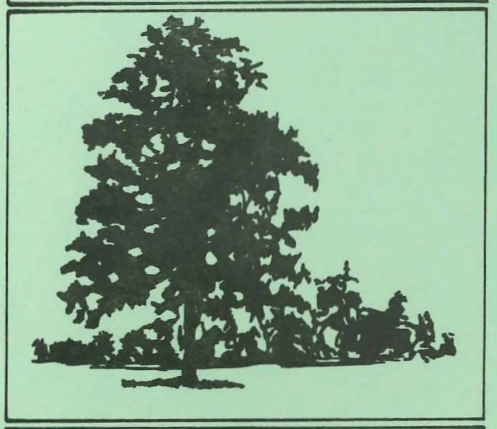

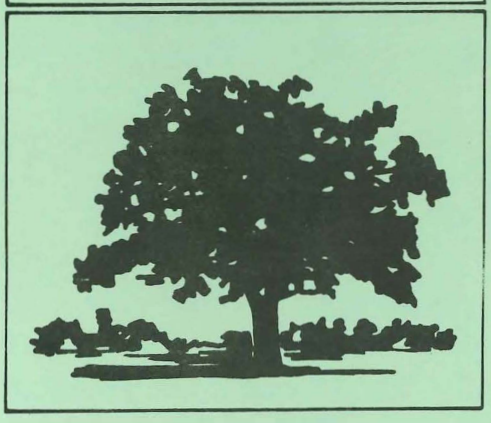

FOREST PEST CONDITIONS IN WISCONSIN

ANNUAL REPORT 1980

DEPARTMENT OF NATURAL RESOURCES
BOX 7921
MADISON, WISCONSIN 53707

FOREST PEST CONDITIONS IN WISCONSIN ANNUAL REPORT - 1980

Compiled and Edited by Donald W. Renlund
Supervisor, Forest Pest Control

DEPARTMENT OF NATURAL RESOURCES
Division of Resource Management
Bureau of Forestry

PREFACE

This record of the activities of forest pests and other destructive agents of growing trees in Wisconsin's forest nurseries, plantations, and natural timber areas was made possible by the dedicated work of pest management personnel in each district and at the Forest Pest Management Laboratory at Nevin Hatchery in Madison. DNR foresters, other department field personnel, cooperators in other public agencies and private forest industry contributed valuable assistance in monitoring the forest lands in all classes of forest ownership.

Preparation of the annual report is the result of the concerted efforts of staff personnel at the Pest Management Laboratory who prepared the final drafts and guided them through typing at the Southern District Office. The finished product was prepared by the Bureau of Office Services.

Many thanks to all who have contributed to the report at any point along the way. Your help was appreciated.

Donald W. Renlund, Supervisor
Forest Pest Management

TABLE OF CONTENTS

Forest Pest Control Personnel.....1

ASPEN.....2
Aspen Blotchminer...Aspen Bronzing...Forest Tent Caterpillar

BALSAM FIR/SPRUCE.....2
Balsam Gall Midge...Balsam Twig Aphid...Spruce Budworm

BASSWOOD.....4
Thrips

BIRCH.....5
Birch Decline... Birch Leafminer...Birch Skeletonizer

BUTTERNUT.....5
Butternut Canker

ELM.....6
Dutch Elm Disease

HEMLOCK.....8
Hemlock Mortality

LARCH.....8
Larch Needlecast...Larch Sawfly

MAPLE.....8
Maple Decline...Orangehumped Mapleworm...Greenstriped Mapleworm...
Maple Trumpet Skeletonizer

OAK.....10
Oak Wilt...Two Lined Chestnut Borer

PINE.....11
Pinewood Nematode...Diplodia Canker...Scleroderris Canker...Red Pine Shoot Blight...
Jack Pine Budworm...Pine Needle Sheathminer...Pine Tussock Moth...Red Pine Needle Midge...
European Pine Sawfly...Introduced Pine Sawfly...White Pine Sawfly...Redheaded Pine Sawfly...
Red Pine Sawfly...Jack Pine Sawfly...Zimmerman Pine Moth...Pine Spittlebug...Saratoga Spittlebug...
White Pine Aphid...Pine Bark Adelgid...Pine Tortoise Scale...Pine Root Collar Weevil...
Pine Root Tip Weevil...Pales Weevil...White Pine Weevil...Northern Pine Weevil...Pine Gall Weevil...
Pine Engraver...White Pine Needle Blight

MISCELLANEOUS TREE SPECIES.....18
Blowdown...Late Spring Frost...Fall Cankerworm...Gypsy Moth

NURSERY PROBLEMS.....19
Swat Team Progress Reports...Pine Seedlings Stunting and Root Rot...Walnut Seed Rot

APPENDIX A.....21
Swat Team Work Plan

APPENDIX B.....22
Soil and Foliar Analysis of Stunted and Non Stunted Red Pine

APPENDIX C.....23
The Effects of Various Cover Crops and Fumigaton on the Soil Populations
of *Fusarium* spp., *Cylindrocladium floridanum*, and Plant Parasitic Nematodes

APPENDIX D.....27
Evaluation of Pathogenic Levels of *Cylindrocladium* and *Fusarium* in
Two State Nurseries in Wisconsin

APPENDIX E.....30
Diplodia pinea in Nursery Seedbeds.

APPENDIX F.....33
Progress Report of Work Completed During the 1980...Field Season Concerning
White Pine Root Rot at Griffith and Wilson State Nurseries

APPENDIX G.....36
Soft Rot of Walnut Seed

Department of Natural Resources
Forest Pest Control Personnel - January 1, 1982

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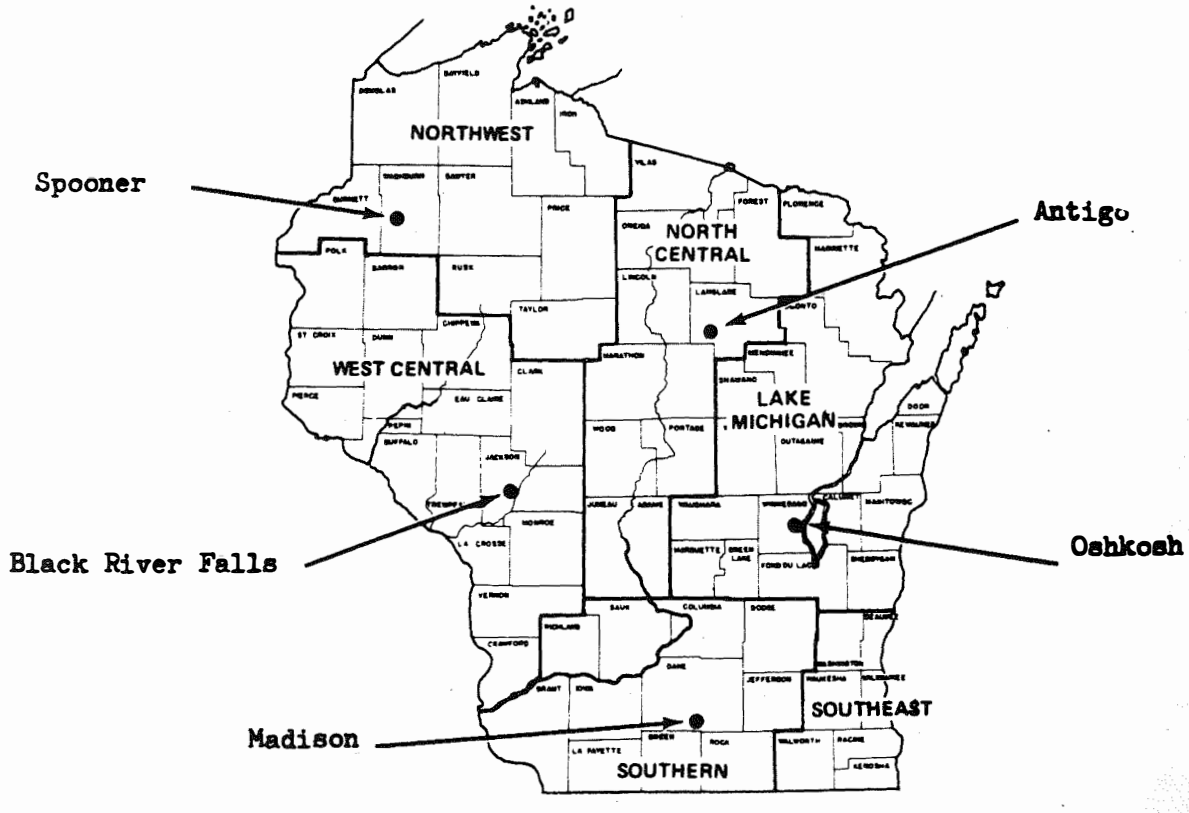

ASPEN

Aspen Blotchminer - *Phyllonorycter tremuloidiella* (Braun)

This leafminer increased in the northeastern counties enough to cause pockets of severe browning of aspen foliage. The most severe damage occurred in Forest, Oneida and Vilas Counties.

Aspen Bronzing - Unknown

An unusual phenomenon has been observed on large-tooth aspen in Wisconsin since 1973. Leaves on individual trees will turn yellow in July and August and within 10-20 days become golden bronze to brown. The remaining leaves on the rest of the tree remain green and healthy. When normal fall coloration occurs, leaves on affected branches are a dark brown with yellow petioles, while unaffected leaves are yellow. Examination the following year reveals that branches bearing bronze leaves are dead. The number of bronze-leaf bearing branches increases each year until the tree dies. No insects or fungi are associated or isolated from the bronzed branches or leaves. Aspen bronzing has been observed in more than 30 locations in Wisconsin (See Forest Pest Condition in Wisconsin-Annual Report, 1979). One new location was found in Vilas County (NWSE, Sec. 17, T40N, R9E). Significant mortality occurred in large tooth aspen stands in Jackson and Trempealeau Counties. Studies are underway at the University of Wisconsin to determine if the leaf bronzing is caused by a virus.

Forest Tent Caterpillar - *Malacosoma disstria* Hubner

Populations erupted to cause light to severe defoliation on 536,000 acres of aspen and oak in the northwestern counties. Local populations were heavy enough that migrating larvae caused slippery roads in northwestern Douglas County. Adult moths were numerous enough to be a nuisance in some localities. Another major increase in area of defoliation is expected in 1981 to the south and east in Douglas, Bayfield and Ashland Counties. Scattered defoliation and moth flights were noted in Washburn, Sawyer and Price Counties. The Wisconsin infestation in western Douglas County is continuous with the forest tent caterpillar outbreak in Minnesota.

Phenology

May 1 - First larvae observed in Douglas County.
June 5 - Larvae mature in Dane County.
July 10 - About 500 adult moths caught in blacklight trap at Spooner in Washburn County.

BALSAM FIR/SPRUCE

Balsam Gall Midge - *Paradioplosis tumifex* Gagne

Populations were extremely high in several balsam Christmas tree plantations in Price, Langlade, Lincoln, Oneida and Oconto counties. Natural stands of balsam fir were heavily infested in Ainsworth Township, Langlade County (T3N, R12E). A heavy population in Shawano County caused little loss of needles. Light damage was reported from a Chippewa County Christmas tree plantation.

Balsam Twig Aphid - *Mindarus abietinus* Koch

Some damage resulted where moderate to heavy infestations occurred in balsam ornamental and Christmas tree plantings in Eau Claire, Jackson, Marquette, Monroe, Waushara, Dane and Door Counties. High populations were sometimes apparently associated with nitrogen fertilization of the trees.

Spruce Budworm - *Choristoneura fumiferana* (Clemens)

The infestation in northeastern Wisconsin continued to increase in area so that it now covers about 180,000 acres of spruce - fir type (Figure 1). Insect numbers generally increased, defoliation increased in area and severity and tree mortality increased over 1979 levels. Egg mass surveys indicated a slight general decline in populations may occur in 1981. In some locations heavy predation of pupae and late instar larvae by an unknown species of stink bug was observed. About 60,000 acres were in the heavy to severe defoliation category.

Scattered infestations in 4 northwestern counties increased the area of visible defoliation nearly 10 fold to about 12,000 acres.

Wisconsin DNR cooperated in the Canada-USA (CANUSA) program in tests with the bacterial insecticide *Bacillus thuringiensis*. The products of 2 major producers were applied by fixed-wing aircraft on 50-acre test blocks in Langlade and Oneida counties on the morning of May 23 to determine their effectiveness as budworm control agents, to evaluate residual life of spray deposits and to determine impact on parasitic insects. Fifteen test blocks were involved. Results will be published by USFS.

Phenology

May 14 - 2nd and 3rd instar larvae mining balsam and white spruce buds in Sawyer, Langlade and Oneida counties.
June 13 - Most budworms in 6th instar; a few are in pupal stage in Langlade County.
June 24 - All of the budworms have pupated and about a third of the adults have emerged in Sawyer County.
July 9 - Egg laying peaked this week in Vilas County.

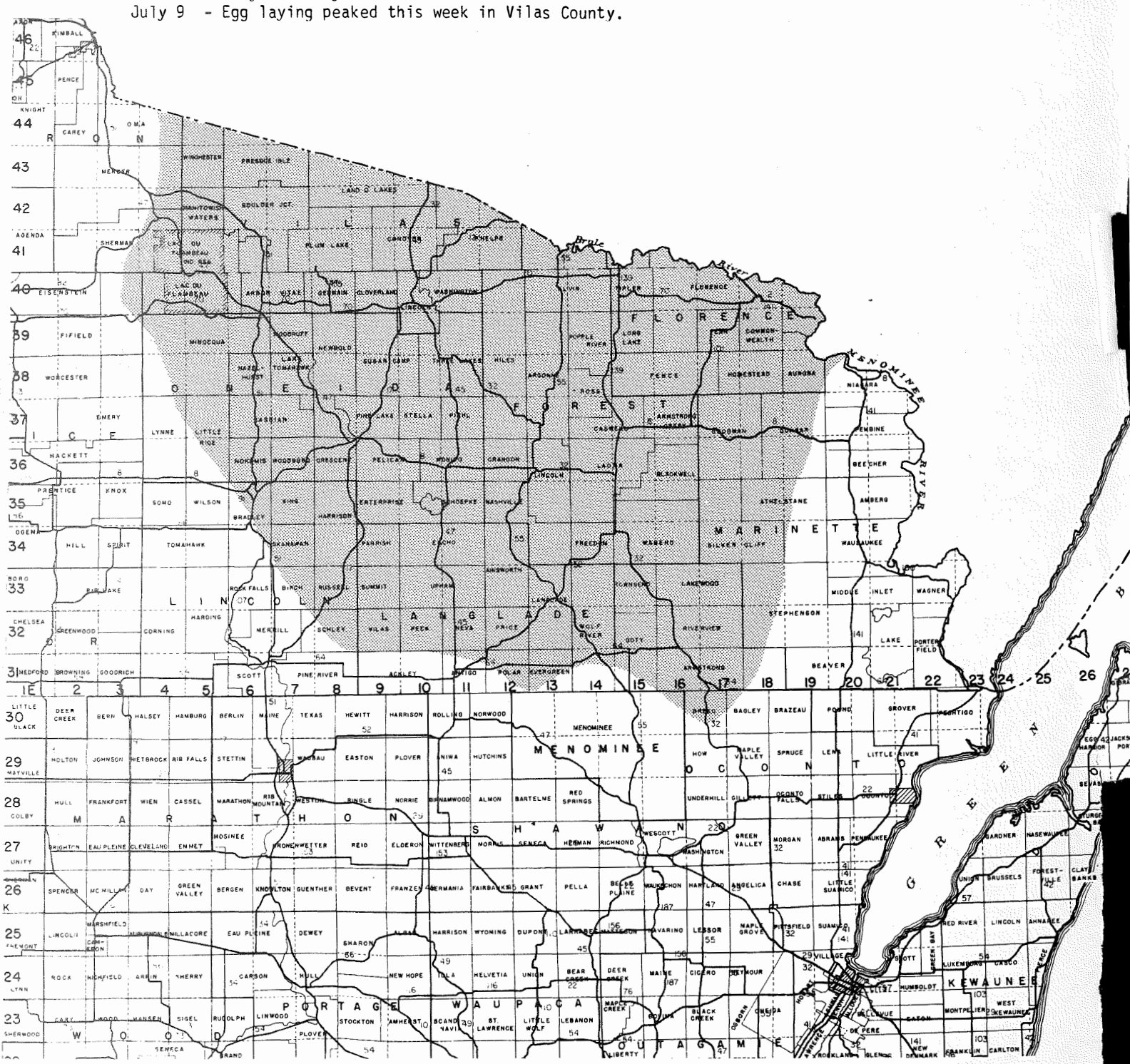

Figure 1. Area of Spruce Budworm Defoliation, 1980.

BASSWOOD

Thrips

A species of thrips caused heavy damage to basswood buds and young leaves in several northeastern counties. The damage resembles the browning caused by late spring frost except that it is limited to basswood. Damage occurred in scattered pockets totalling about 2,000 acres in Forest and Oneida Counties (Figure 2).

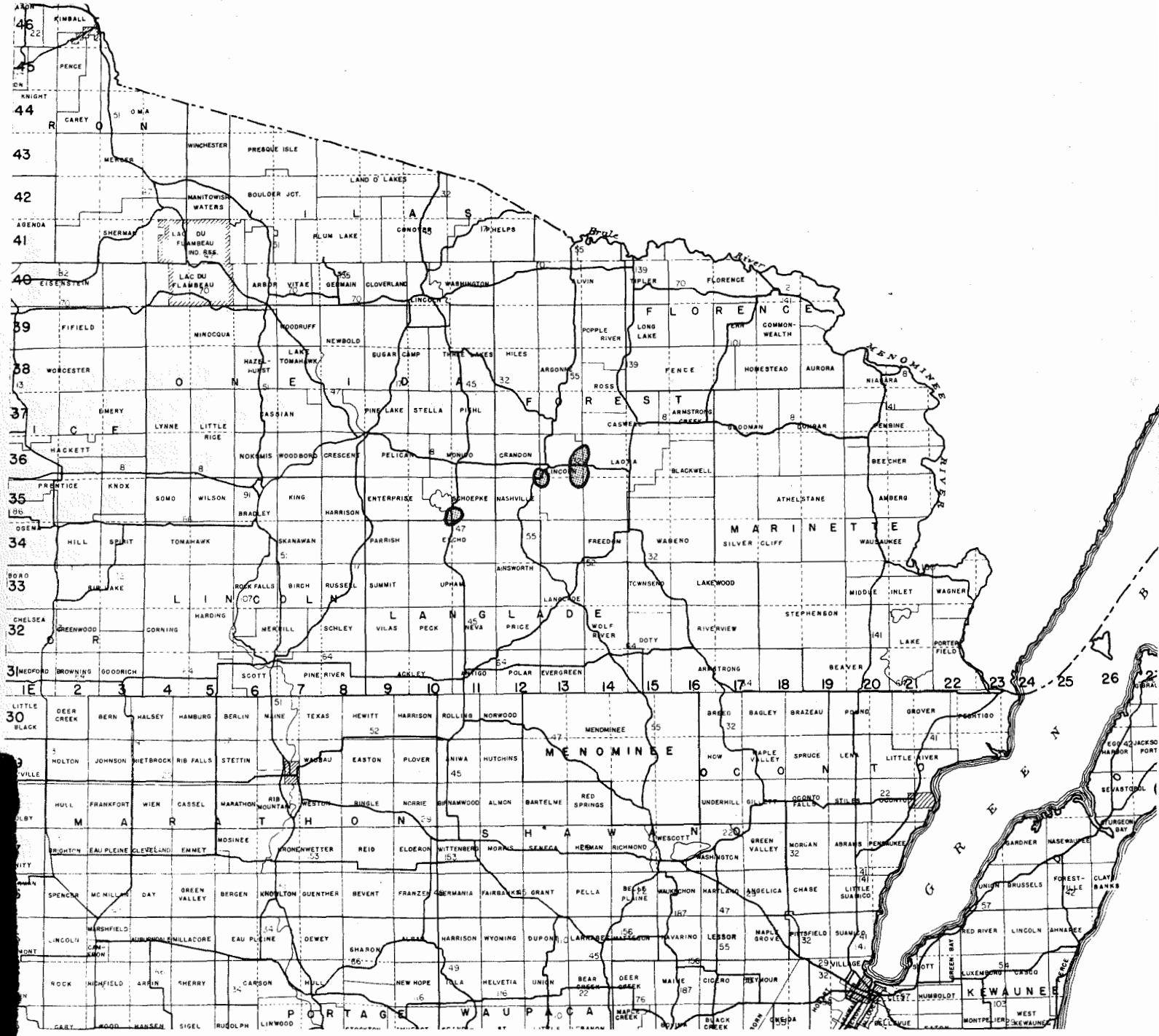

Figure 2. Area of Damage Caused by Basswood Thrips, 1980.

BIRCH

Birch Decline

Birch and other tree species were placed under unusual stress during the severe drought which affected most of the state in 1976 and part of 1977. Additional stress to birch trees has been caused by successive infestations of birch leaf miner early in the growing seasons followed by infestations of the birch skeletonizer. Successful attacks by bronze birch borers and other wood invaders have followed as a result of these stresses. Many of the birch trees have died across the northern counties the last three years. In some stands, the progressive mortality in the tree crowns has ceased as growing conditions improved with normal rainfall.

Birch Leafminer - *Fenusa pusilla* (Lepeletier)

Leaf mining on ornamental birch was evident over much of Wisconsin. Significant damage to forest trees occurred principally in the northern half of the state. Damage was moderate in the northwest and very heavy in pockets in the northeastern counties.

Birch Skeletonizer - *Bucculatrix canadensisella* Chambers

Populations were high over all except the southeastern quarter of Wisconsin. Late summer browning of white birch leaves caused many complaints from the public. In the northwestern counties, where populations have been high since 1978, the amount of browning decreased somewhat in 1980.

BUTTERNUT

Butternut Canker - *Sirococcus clavigignenti-juglandacearum* Nair, Kost and Kuntz

There has been no change in the distribution of butternut canker in Wisconsin (Figure 3).

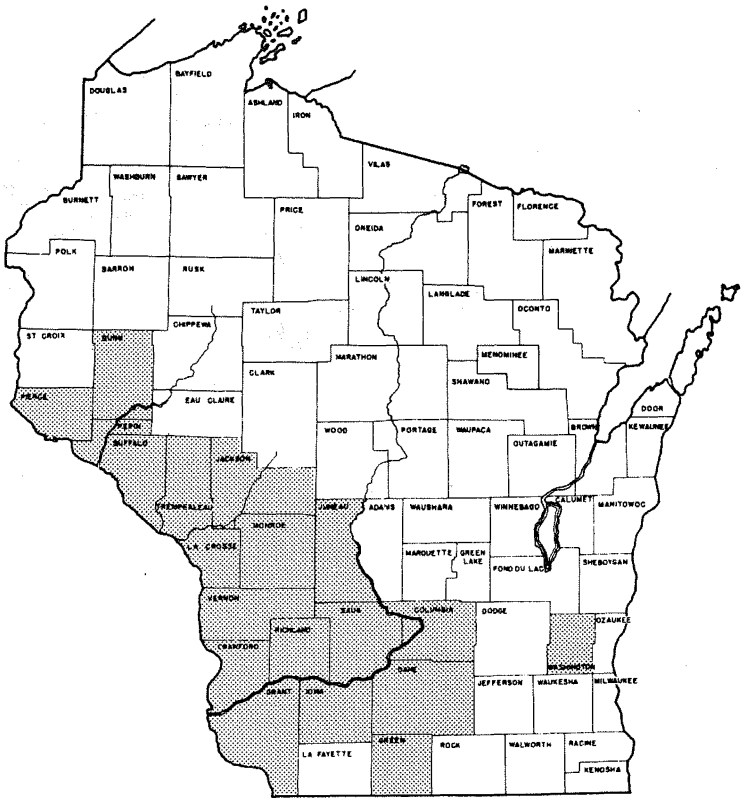

Figure 3. Known County Distribution of Butternut Canker in Wisconsin, 1980.

ELM

Dutch Elm Disease - *Ceratocystis ulmi* (Buisman) Moreau

Dutch elm disease was first reported in Wisconsin in 1956. By 1978, about 50% of the elms were alive as the disease moved upstate rapidly along the waterways in raw wood products and by other means. In 1980, an estimated 80-90% of the elms in northeastern Wisconsin were infected with DED. About 500 million cubic feet of elm died from the disease between 1968 and 1978; approximately 200 million cubic feet were utilized.

In 1980 seventeen communities participated in a $450,000 DED control demonstration program sponsored by the USDA-Forest Service. Originally, twenty communities participated. Three dropped out for various reasons. This year, disease losses have been reduced as much as 50% in some communities (Table 1). More than 600 cords of elm firewood and 4,000 cubic yards of chips have been produced from diseased elms within the participating communities (Table 2).

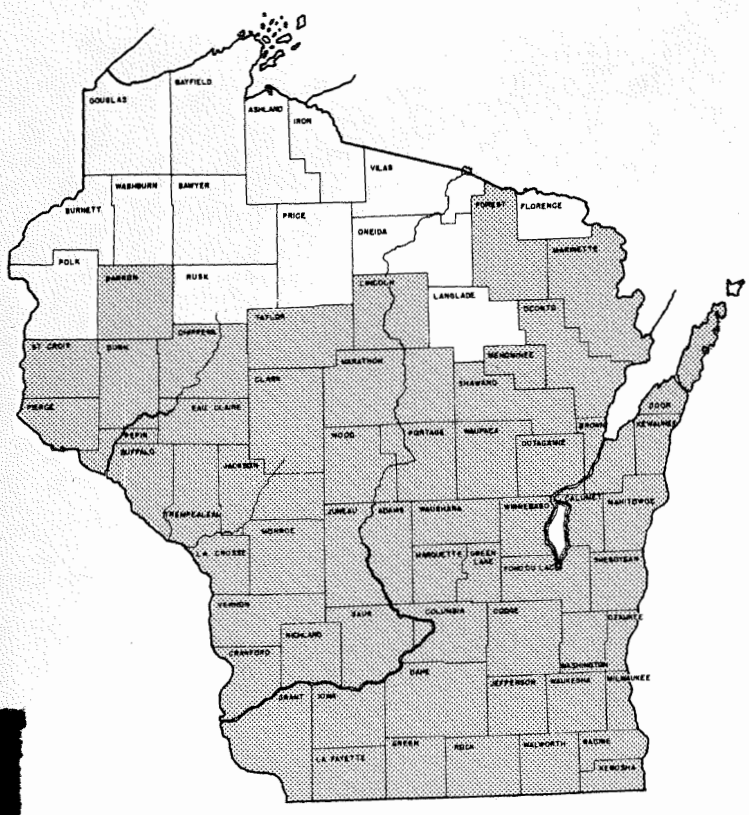

Figure 4 - Known County Distribution of the Small European Elm Bark Beetle, 1980.

Figure 5. Known County Distribution of the Native Elm Bark Beetle, 1980.

Community	Elm Inventory 5/1/78 (No.)	Dutch Elm Disease Losses 1978 No.[a]	1978 %[b]	1979 No.[a]	1979 %[b]	1980 No.[a]	1980 %[b]	Elm Inventory 9/30/80 (No.)
Allouez	1,815	393	21.6	410	22.6	177	9.7	835
Bayside	5,024	90	1.8	126	2.5	85	1.7	4,723
Bloomer	1,642	30	1.8	167	10.2	45	2.7	1,400
Eau Claire	37,000	966	2.6	700	1.9	566	1.5	34,768
Elm Grove	8,795	274	3.1	254	2.9	254	2.9	8,013
Fox Point	4,900	280	5.7	570	11.6	184	3.7	3,866
Hudson	6,376	526	8.2	573	9.0	338	5.3	4,939
Milwaukee	2,472[c]	216[c]	8.7	108[c]	4.4	112[c]	4.5	2,036
Monona	2,088	488	23.4	230	11.0	58	2.8	1,312
Neillsville	4,100	219	5.3	179	4.4	71	1.7	3,631
Onalaska	2,440	136	5.6	252	10.3	108	4.4	1,944
Rhinelander	2,016	341	16.9	237	11.8	111	5.5	1,327
River Hills	2,900	600	20.7	458	15.8	35	1.2	1,807
Tomah	2,392	750	31.3	722	30.2	171	7.1	749
Wauwatosa	8,301	747	9.0	518	6.2	554	6.7	6,482
Whitefish Bay	4,578	317	6.9	323	7.0	183	4.0	3,755
Wisconsin Rapids	8,322	1,058	12.7	1,216	14.6	905	10.9	5,143
TOTAL	105,143	7,431	7.1	7,043	6.7	3,957	3.8	86,733

[a]Includes removal of both public and private elms.

[b]Percent calculation based on elm inventory at start of program, 1978.

[c]Numbers represent elms only within designated intensive Dutch Elm Disease management zone.

Table 1. Municipal elm losses 1978-80.

Table 2. Projected and actual amounts of elms harvested and products produced.

Municipality	Number of Elms Harvested		Amount Products: Firewood (cords)		Amount Products: Wood Chips (cu. yd.)	
	Projected	Actual	Projected	Actual	Projected	Actual
Allouez	400	177	200	35 1/3	80	120
Bloomer	300	78	150	81		
Eau Claire	400	124	200	151	80	a
Hudson	500	157	250	98	100	a
Neillsville	120	100	100	83		
Onalaska	150	7	100	12.5		
Rhinelander	200	98	150	88 2/3		
Wisconsin Rapids	400	108	200	91	80	110
Wauwatosa, Bayside Elm Grove, Fox Point Whitefish Bay, Milwaukee	1410	930			3400	3487.5
Total	3880	1779	1350	640.5	3740	3717.5

a. No yardage measurements are available.

HEMLOCK

Hemlock Mortality

Heavy mortality of mature eastern hemlock has occurred over the past several years on the Menominee Indian Reservation. Contributing factors are: age which varies from 285-300 years; the 1976-77 drought; root rot *(Armillaria mella)* which appears to be the major cause of mortality and hemlock borer *(Melanophila fulvoguttata)*.

Aerial surveys have been conducted annually to locate and map concentrations of mortality for the ongoing salvage operation. Estimates of the volume involved are being compiled.

LARCH

Larch Needlecast - *Mycosphaerella* sp.

Mycosphaerella needle cast of European larch was first reported in North America this year (1980) from larch plantations planted between 1966 and 1968 in LaCrosse and Trempealeau Counties. Until this year, it was found on larch only in Europe and Japan. No tree mortality was observed, but twig and branch dieback may have been caused by previous defoliation. Progress of the disease will be monitored in 1981.

Larch Sawfly - *Pristiphora erichsonii* (Hartig)

Populations decreased over most of Wisconsin. Pockets of moderate to heavy defoliation occurred in the northwestern counties and in Langlade and Oneida Counties.

The parasite, *Olesicampe benefactor* Hinz was reared from cocoons collected in August, 1979, in Clark County. This is the first Wisconsin record of this Ichneumonid which was introduced from Europe into Canada and from there into northern Minnesota.

MAPLE

Maple Decline

A disease, predominantly of urban sugar maples of all ages and sizes, first manifests itself as early color change, usually in late July and August. Symptoms may start on one part of the tree, usually the upper crown, and increase over a period of several years to a point where leaves become small and less abundant. Frequently the tree produces heavy seed set. Large branches die one by one until finally the tree is completely dead. Infected trees rarely recover, but watering and fertilizing may prolong their life.

Shallow planting, distribution of roots and avoidance of injury to the lower trunk my help to avoid the problem. The disease is common in many communities, particularly in southern Wisconsin. Naturally occuring woodland trees are shallow rooted and rarely develop the disease, except when grown on sites affected by drought (see Forest Pest Conditions in Wisconsin - 1979 Annual Report).

Orangehumped Mapleworm - *Symmerista leucitys* Franclemont

This normally rare late-summer defoliator increased in numbers so that larvae were commonly observed in northern hardwood stands in the northeastern counties. Higher numbers are expected in 1981.

Greenstriped Mapleworm - *Dryocampa rubicunda* (Fab.)

Pockets of severe defoliation of red maple totalling about 350 acres were observed in Cloverland Township in Vilas County (T40N, R9E).

Maple Trumpet Skeletonizer - *Epinotia aceriella* (Clemens)

An outbreak of this late summer defoliator originated in 1979 when defoliation was noted in Langlade County. In 1980 skeletonized leaves were evident on most sugar maple in the northern half of the state. A pocket of heavy defoliation covering 3,000 acres occurred in Forest County. Small pockets of moderate to heavy defoliation occurred in several other northern counties (Figure 6).

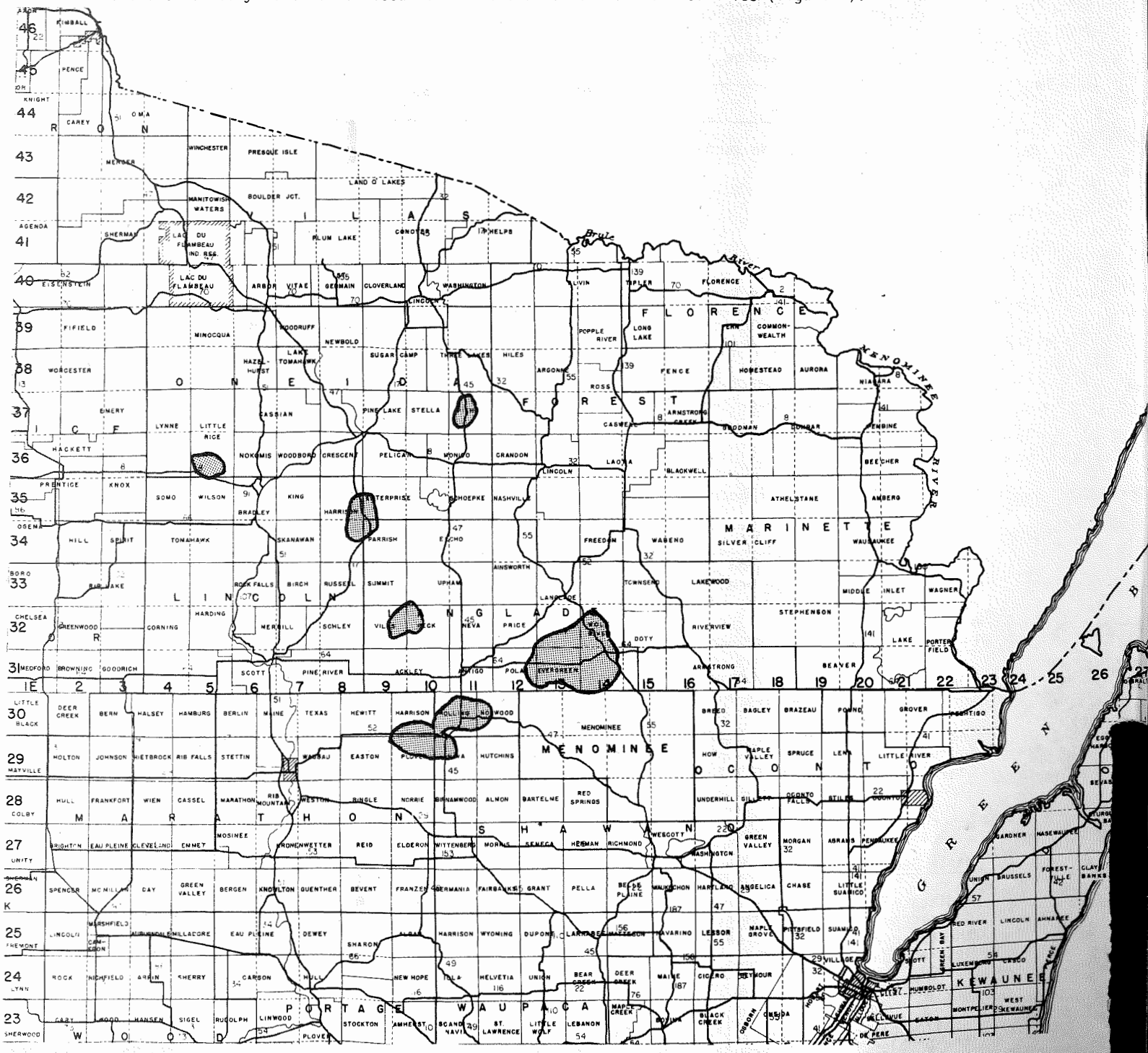

Figure 6. Area of Defoliation Caused by Maple Trumpet Skeletonizer, 1980.

OAK

Oak Wilt - *Ceratocystis fagacearum* (Bretz) Hunt

The disease is active in oak stands over most of the southern two thirds of the state except counties bordering Lake Michigan north of Ozaukee County and including Calumet and Brown counties.

The European Economic Community (EEC) accepts logs and other wood from known oak wilt free areas in the state, but not from counties where the disease is known to be present (Figure 7). Wood from infected counties may be shipped, provided it meets conditions stipulated by the participating countries. Regulations concerning oak shipments to these countries are being revised for 1981. Currently, the presence of one infected tree in a county is enough to prevent movement of oak to EEC countries unless it has been properly treated.

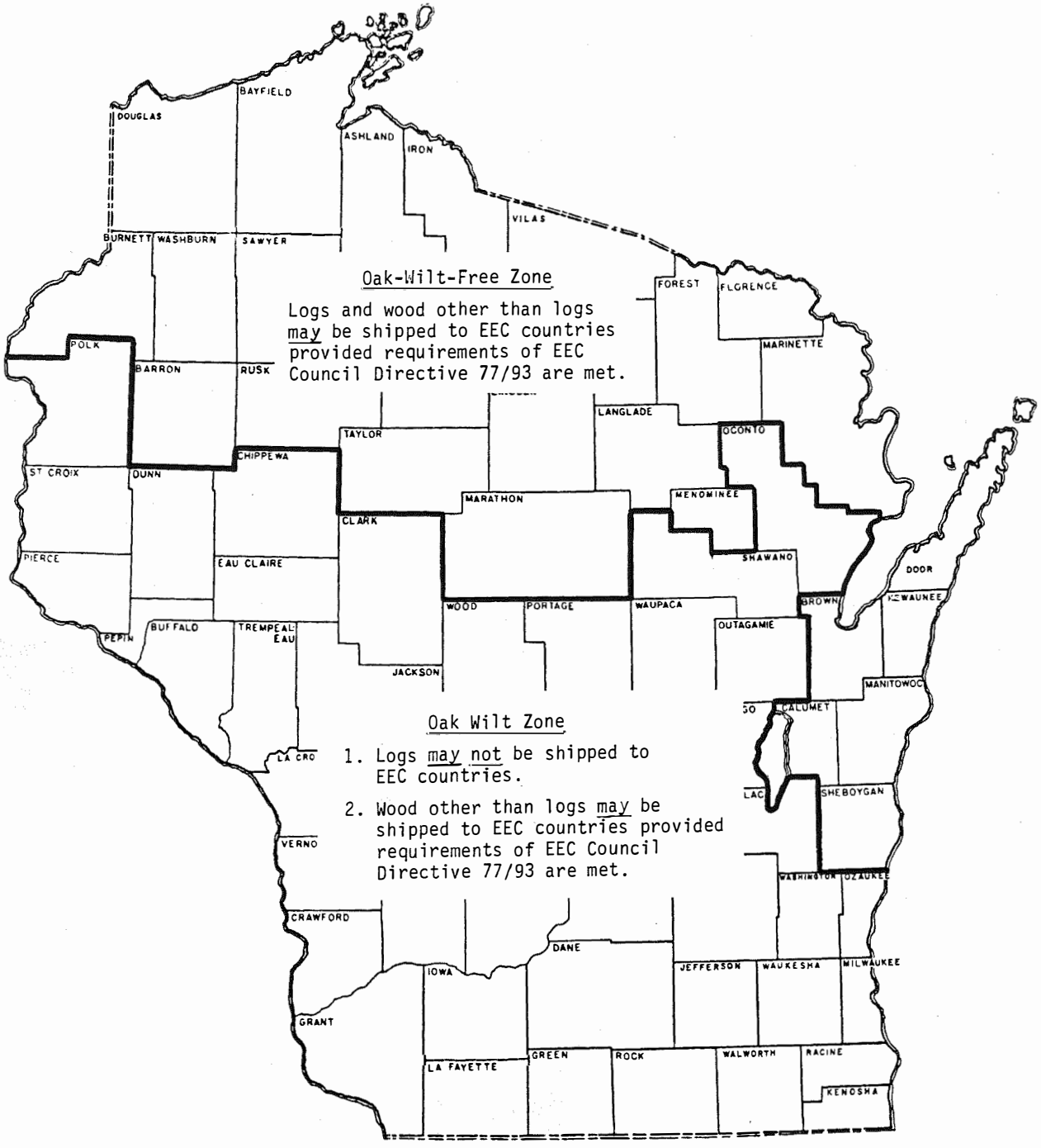

Figure 7. Oak Wilt and Oak Wilt Free Zones in Wisconsin, 1980.

Twolined Chestnut Borer - *Agrilus bilineatus* (Weber)

Damage to oaks by ths borer was extremely low over the entire state. The few oaks that were killed by the borer on the Kettle Moraine State Forest - Southern Unit had been attacked previously.

PINE

Pinewood Nematode - *Bursaphelenchus lignicolus* Mamiya and Kiyohara

This nematode was first recorded in Wisconsin in June, 1980, when it was found in Austrian pine in Pepin County by U.S. Forest Service researchers. It has since been isolated from red, jack, Austrian and Scotch pine from one or more locations in 16 Wisconsin counties (Figure 8).

Baermann funnels have been used in the DNR lab to extract nematodes from suspect wood samples. A sample of about 30cc of wood was chipped in to small pieces and placed in distilled water in a funnel for 24-48 hours. Emerging nematodes were checked only for the presence of the distinctive male pinewood nematode.

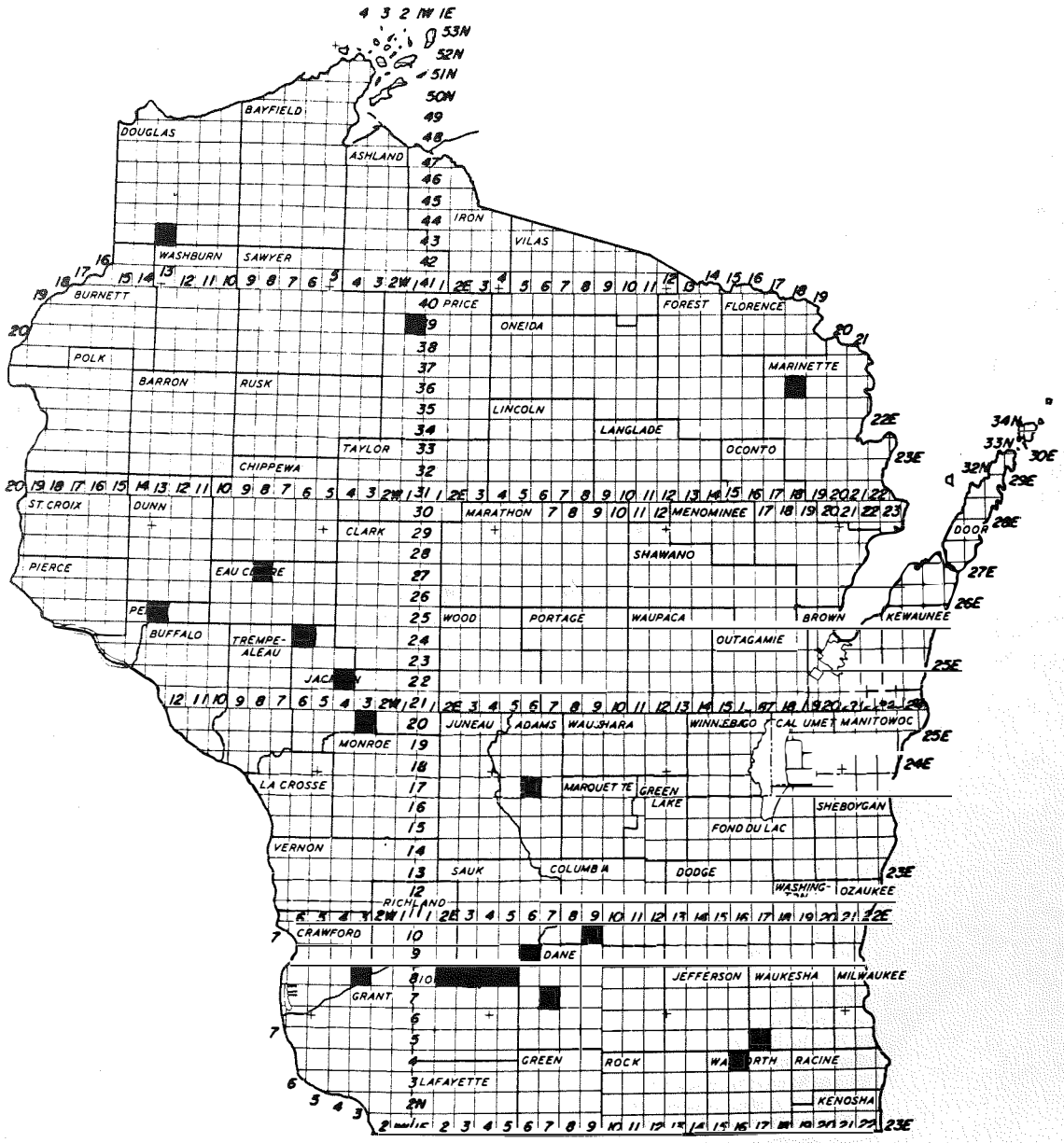

Figure 8. Township Locations of the Pinewood Nematode in Wisconsin, 1980.

Most of the positive samples of red pine have yielded one or two dozen adult male pinewood nematodes. A sample from a Marinette County red pine that had been damaged by Saratoga spittlebug yielded hundreds of male pinewood nematodes. Near Durand in Pepin County, the incidence of the nematode was very high in dead Austrian pines which were heavily infested with Dothistroma needlecast. Adjacent red pines were healthy. Near Shamrock in Jackson County, the nematode was isolated from red and jack pines that were also infested with Diplodia canker and pine root weevil. Near Spring Green in Sauk County, two pockets of mortality began showing up in a 35 year old red pine plantation in 1973. Trees at the edges of the pockets declined in height growth for one or two years before dying. The pine engraver (*Ips pini*) has always been found in the dead trees. Intensive examination of the soil, roots, foliage and wood revealed nothing that should make the trees susceptible to bark beetles. The PWN was isolated from several dead trees in these pockets this year.

The results from wood samples checked for pinewood nematodes by U.S. Forest Service, Wisconsin Department of Agriculture and Wisconsin DNR were combined (Table 3). These data include only samples of wood from dead trees or dead tops and must be viewed with caution because many different methods of sampling have been employed and the samples were taken at different time intervals following the death of the material collected.

TABLE 3. Pinewood Nematode *(Brusaphelenchus lignicolus)* collections in Wisconsin - 1980.

Tree Species	Trees Sampled (No.)	Trees With Pinewood Nematode (No.)	(%)
White pine	6	0	0
Jack pine	31	5	16
Red pine	48	15	31
Scotch pine	13	6	46
Austrian pine	14	11	78
TOTALS	112	37	33

The Pinewood Nematode has not yet been isolated from white pine in Wisconsin. The incidence of the nematode has been highest in the two tree species that are not native to North America. Because the nematode was quickly found over the entire United States and all across Wisconsin after its discovery here, it is considered native to North America.

Diplodia Canker - *Diplodia pinea* (Desm.) Kilk

There was no change in the county distribution of Diplodia canker and shoot blight in Wisconsin (Figure 9), but Diplodia shoot blight continued to cause mortality of redpine seedlings at Wilson and Griffith State Nurseries.

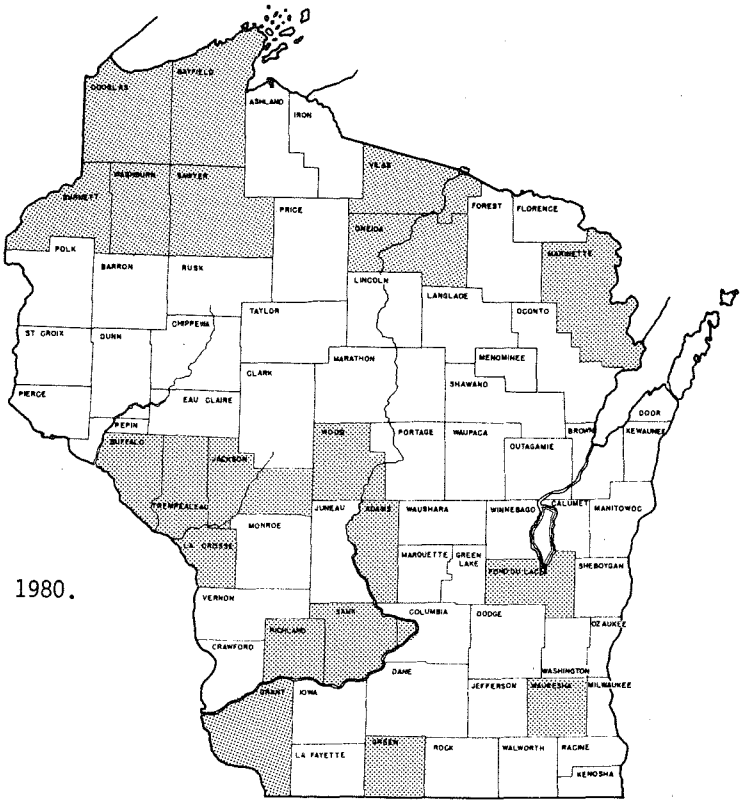

Figure 9. Known County Distribution of Diplodia Canker in Wisconsin - 1980.

Scleroderris Canker - *Scleroderris lagerbergii* Grenmen

There was no change in the distribution of Scleroderris canker in Wisconsin (Figure 10). Nine red pine plantations are known to be infected on state and private lands in Wisconsin - 4 in Bayfield County and 5 in Vilas County (Forest Pest Conditions in Wisconsin - 1977 Annual Report). Additional plantations are affected on national forest land in northern Wisconsin. Tree mortaility continues in infected plantations. Infection appears to occur within the first 10 years of establishment. Annual surveys of plantations have revealed no new infected ones on state or private lands. The European strain has not been identified in serological testing of Wisconsin samples. No testing was done in 1980.

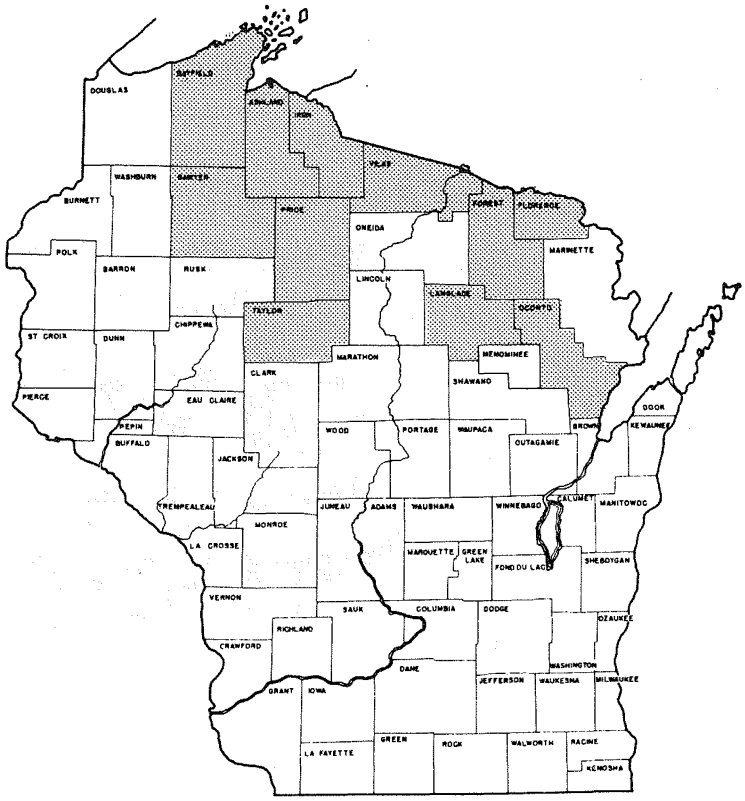

Figure 10. Known County Distribution of Scleroderris Canker in Wisconsin, 1980.

Red Pine Shoot Blight - *Sirococcus strobilinus* (Pruess)

Infection of current years shoots continued on previously infected sites on the Northern Highland State Forest and the Nicolet National Forest. Infected red pines are most commonly found in the Northern Highland State Forest in Boulder Junction, Starr Lake and Sayner Areas, others are in the Nicolet National Forest along forest road 2183 and 3865 east of Three Lakes and 2178 north of Hwy. 70 east of Eagle River. An additional location was recorded in 1980 (SENE, S12, T41N, R10E, Vilas County).

There has been no change in the county distribution of red pine shoot blight since 1974 (Figure 11). But there was a continuing number of infected current year's shoots (80% infected) and tree mortality in understory trees within plots on the Northern Highland State Forest (Table 4).

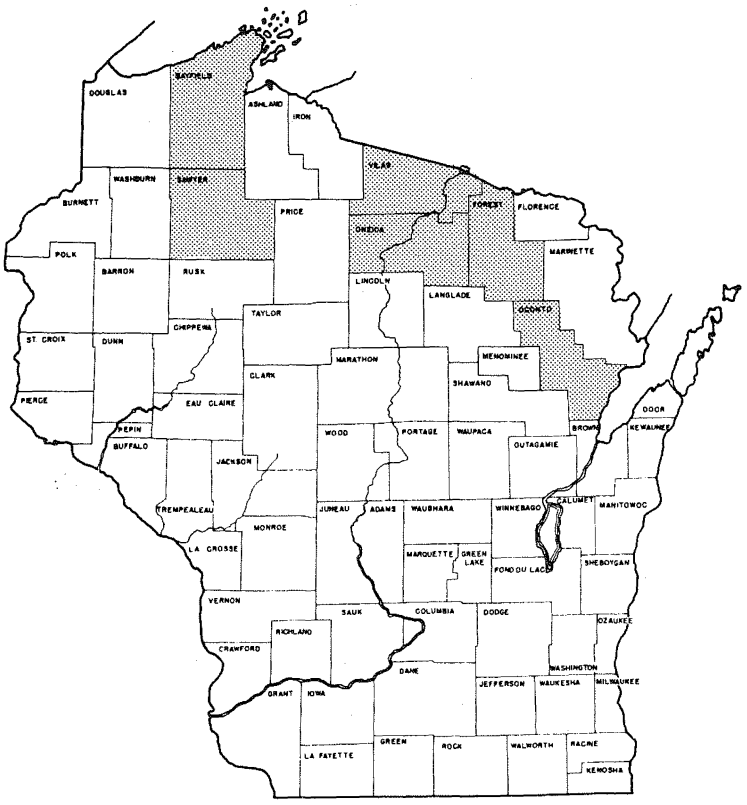

Figure 11. Known Distribution of Red Pine Shoot Blight in Wisconsin - 1980.

Table 4. Cumulative tree mortality, Starrett Lake Red Pine Shoot Blight Plot, Northern Highland State Forest, Vilas County, Wisconsin (Sec. 24, T41N, R7E).

Year	Location	
	Opening (%) 1/	Understory (%) 1/
1972	0	20
1973	0	31
1974	0	45
1975	0	59
1976	0	63
1977	0	67
1978	0	76
1979	0	No Data
1980	0	88

1/% of total no. of trees in plots.
Plot total: number of trees in openings - 49
: number of trees in understory - 51

Jack Pine Budworm - *Choristoneura pinus* Freeman

The infestation in the northwestern Wisconsin increased in size to 40,000 acres and caused light defoliation of jack pines. An egg survey indicated that about half of this area should support high populations in 1981 with some moderate and heavy defoliation.

In northeastern Wisconsin light to moderate defoliation occurred on 6,000 acres of Jack Pine in the Menomoniee Reservation. Heavy predation of larvae and pupae by a Pentatomid bug was noted; an egg survey turned up no eggs. Pockets of light defoliation occurred in scattered jack pine stands in Marinette County. In west central Wisconsin light populations in Jackson County caused no noticeable defoliation.

Pine Needle Sheathminer - *Zelleria haimbachi* Busck

Unusually high populations of this small, lavender-striped caterpillar were found during jack pine budworm surveys in a small area in Jackson County. Light defoliation appeared to be due to this insect rather than the budworm. Larvae were heavily parasitized by a small, white cocooned ichneumonid wasp.

Pine Tussock Moth - *Dasychira pinicola* (Dyar)

A light, but increasing population along the Douglas-Bayfield County boundary caused no noticeable defoliation but the potential exists for an outbreak in 1981. Serious defoliation could occur on 20,000 acres of jack and red pine. Evidence of heavy egg parasitism by *Trichogramma minutum* was noted in some egg samples.

Red Pine Needle Midge - *Thecodiplosis piniresinosae* Kearby

Populations remained high over much of Wisconsin where red pines have been planted on sandy soil; however, defoliation decreased by 50% in many plantations in Clark, Eau Claire and Jackson Counties.

European Pine Sawfly - *Neodiprion sertifer* (Geoffroy)

Populations increased dramatically in Jefferson, Walworth and Waukesha counties where 1,500 acres of red pine plantations contained heavy to severe defoliation. Elsewhere in the southern counties, local infestations generally remained at low densities. Reports of light defoliation were received from Dane and Grant counties.

The northern limit of the range of the insect is gradually moving northward (Figure 12) in the eastern portion and remaining about stationary elsewhere.

The heavy population in the eastern counties occupies rough, gravelly kettle moraine soils that have been planted to red pine over the last 40 years. The area contains the Southern Unit of the Kettle Moraine State Forest which contains a large acreage of red pine. Surrounding farm land has scattered plantations of red pine and (to a lesser extent) scotch pine. The heavy defoliation occurs on trees 20 ft. or less in height. Older plantations are very lightly defoliated.

The parasite, *Lophyroplectus oblongopunctatus* (Hartig) which was released in 1977 in the Kettle Moraine State Forest and recovered from larvae collected in 1978, was reared from about 3% of larvae collected within 100 yards of the release site in 1979. The adults, which are an unusual bright orange color, were observed occasionally in the release area in 1980. About 1,500 host larve were collected to monitor the parasite population. Another 10,000 were collected in order to rear and release more adult *L. oblongopunctatus* in 1981.

The nuclear polyhedrosis virus of the sawfly was introduced into Wisconsin in 1979 when U.S. forest researchers sprayed test plots in the Kettle Moraine State Forest. In 1980 the sample plots were sprayed again. At that time (1980) 200 colonies of 2nd and 3rd instar larvae were fed for two days on foliage sprayed with the virus. These colonies were then placed in healthy sawfly populations in five locations in Walworth and Waukesha counties on May 22. The locations were rechecked on June 25. The effects of the innoculations were variable. No spread of the virus from innoculated trees to adjacent trees was observed based on appearance of sawfly colonies. In some instances no spread was observed from contaminated colonies to healthy colonies on adjacent branches. In most cases, some within-tree spread was observed and in some cases the virus had killed all the colonies on single trees.

Virus innoculations in more infestations are planned for 1981; emphasis will be placed on the leading edge of the range in Waukesha and Washington counties.

Introducted Pine Sawfly - *Diprion similis* (Hartig)

Populations continued their downward trend. A single report of defoliation was received.

White Pine Sawfly - *Neodiprion pinetum* (Norton)

A few reports of defoliation were received from Grant, Crawford, Buffalo and Trempealeau counties.

Redheaded Pine Sawfly - *Neodiprion lecontie* (Fitch)

Populations increased in the northeastern counties. Of 2,000 acres surveyed in Menominee, Vilas, Langlade and Oneida counties, 90 acres were treated with Malathion. Small infestations were also found in Shawano and Waupaca Counties.

Red Pine Sawfly - *Neodiprion nanulus nanuluus* (Schedl)

Populations that had been high in 1978 and low in 1979 rebounded in 1980 in Sauk, Columbia and Marquette counties. About 350 acres of planted pole sized red pine were heavily defoliated. Very light defoliation occurred in pole sized red pine on the sandy lowlands along the Wisconsin River in Sauk, Iowa and Richland counties.

Jack Pine Sawfly - *Neodiprion pratti banksianae* Rohwer

A light infestation was observed on jack pine within the red pine sawfly outbreak area in Sauk County.

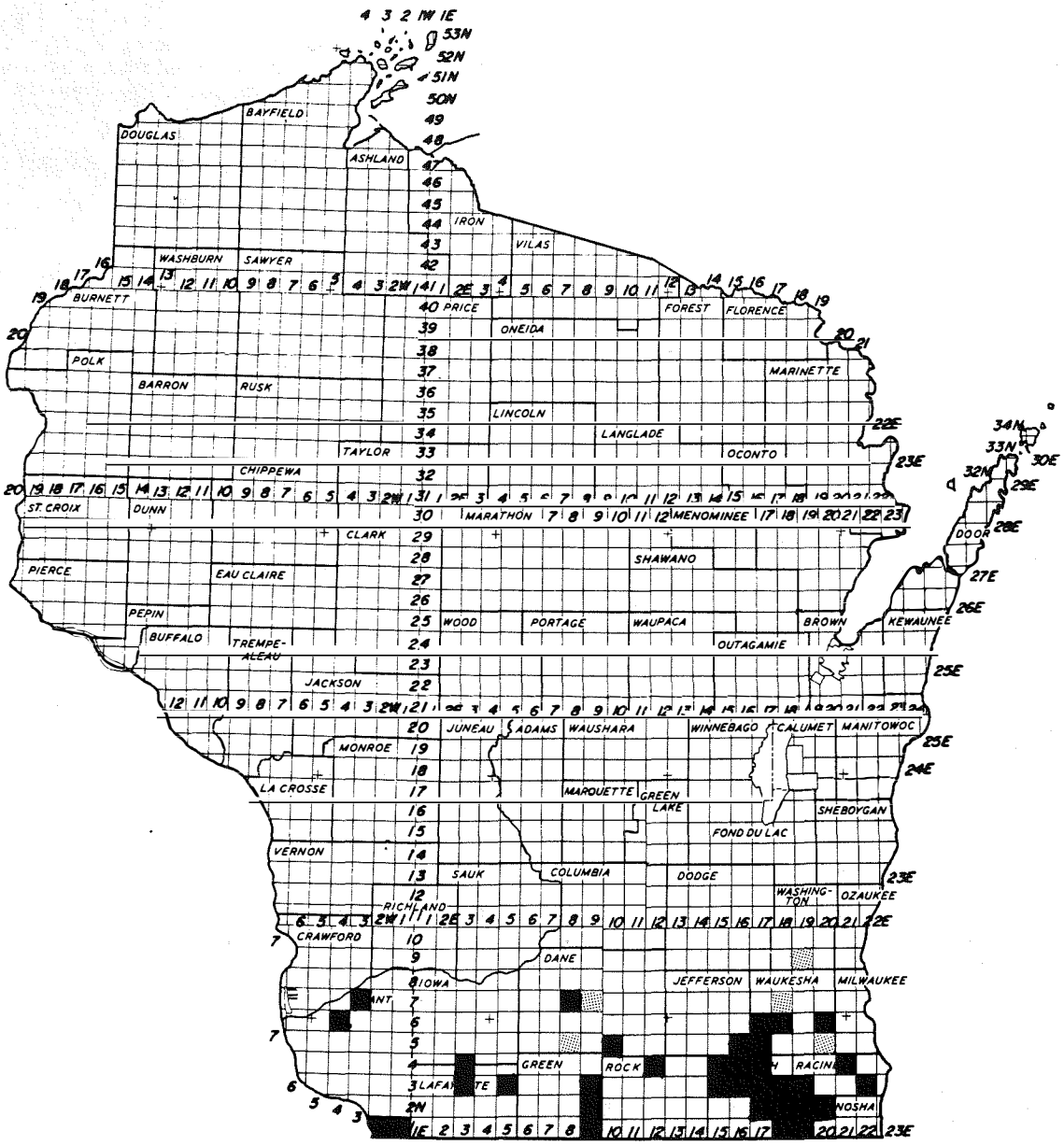

Figure 12. Known Township Locations of European Pine Sawfly Infestations; 1972-1979 (solid), 1980 (dotted).

Zimmerman Pine Moth - *Dioryctria zimmermani* (Grote)

Heavy attack on red pine terminal shoots continued in the central counties. Many 15-45 year old stands in Jackson County and Waushara County have been heavily attacked for five consecutive years. Virtually all of the trees in these plantations have been attacked. The loss in height growth corresponds to a decrease in sight index from an actual 73 to apparent 67. In some plantations this loss amounts to about 1 pulp stick per tree.

Some younger (10-25 year-old) plantations have been heavily attacked for one or two years.

Pine Spittlebug- *Aphrophoa parallela* (Say)

Heavy populations have been present in many west central jack and Scotch pine stands for several years causing considerable flagging and twig mortality in Scotch pine.

Saratoga Spittlebug - *Aphrophora saratogensis* (Fitch)

A survey of 1,700 acres of susceptible red pine plantations in the North Central counties revealed 90 acres that required treatment. An aerial application of ULV Cythin was applied to 72 acres at 10 fl. oz. per acre on Menomiee Tribal Lands. Several 5-7 acre plantings were treated with Malathion by mist blowers at a rate of 1/2 lb. A.I. per acre on private land in Langlade and Oneida Counties. Results were generally good.

A 12 acre red pine plantation in Marinette County was virtually destroyed by heavy spittlebug attack.

White Pine Aphid - *Cinara strobi* (Fitch)

Scattered pockets of heavy populations were observed in the northeastern counties and in the south central counties.

Pine Bark Adelgid - *Pineus Strobi* (Hartig)

Very heavy local infestations were observed on pole-sized white pine in the central and southern counties.

Pine Tortoise Scale - *Toumeyella parvicornis* (Cockerell)

Several small but heavy infestations were noted in Jackson and Clark Counties. Most of them were infecting jack pine that is invading old fields; one was in a Scotch pine plantation.
A heavy population was reported in a young jack pine plantation in Marinette County.

Pine Root Collar Weevil - *Hylobius radici* (Buchanan)

Heavy scotch pine mortality occurred in a Waushara County plantation that was originally meant for Christmas trees and then left untended. In other areas scattered scotch pine mortality continued in old infestations.

Pine Root Tip Weevil - *Hylobius rhizophagus* (Millers)

Flagging and mortality continued in known infestations in jack and red pine in Jackson County. Natural scotch pine regeneration in Waushara was heavily damaged. In an Adams County red pine plantation heavy flagging and stunting occurred in pockets around individual older jack pines.

Pales Weevil - *Hylobius pales* (Herbst)

A few scattered reports of twig damage were received from the central and southern counties.

White Pine Weevil - *Pissodes strobi* (Peck)

Damage to white and jack pine terminals continued to increase over the northern three fourths of the state. Dead terminals were commonly visable in July and August. Heavy damage to white and jack pine in Jackson County was reported.

Northern Pine Weevil - *Pissodes approximatus* (Hopkins)

Damage was generally light. White pine Christmas trees in Rock County were heavily damaged by adults feeding on twigs.

Pine Gall Weevil - *Podapion gallicola* (Riley)

The first report in several years of this gall former in pine twigs was received from the forest nursery at Hayward where red pine windbreaks were heavily attacked.

Pine Engraver - *Ips pini* (Say)

The dry spring and early summer contributed to build-up of first generation beetles and made trees susceptible to attack in mid and late summer. Numerous pockets of mortality occurred in 10-40 year old planted red pines growing on the sandy lowland of the Wisconsin River from Dane to Richland County.

Some build-up occurred on winter-cut pine pulpwood decks that were left in the woods in some central counties.

White Pine Needle Blight - Atmospheric Gases

White pine needle blight which can be caused by atmospheric gases such as ozone or sulfur dioxide, was observed in early August on white pines growing near Clam Lake Wisconsin. Most of the current year's needles were entirely blighted; others were 2/3 blighted indicating the damage may have occurred in late June or early July.

MISCELLANEOUS TREE SPECIES

Blowdown

A windstorm on July 15, 1980 destroyed the timber on 150,000 acres of forest land in west central Wisconsin (Figure 13). Major damage occurred in Dunn and Eau Claire counties, but was also severe in Chippewa, Pierce and Clark counties. Efforts are underway to salvage 57,000,000 board feet of hardwoods, 8 million board feet of conifers, 209,000 cords of hardwood pulpwood and 25,000 cords of soft wood pulpwood that was damaged by the storm.

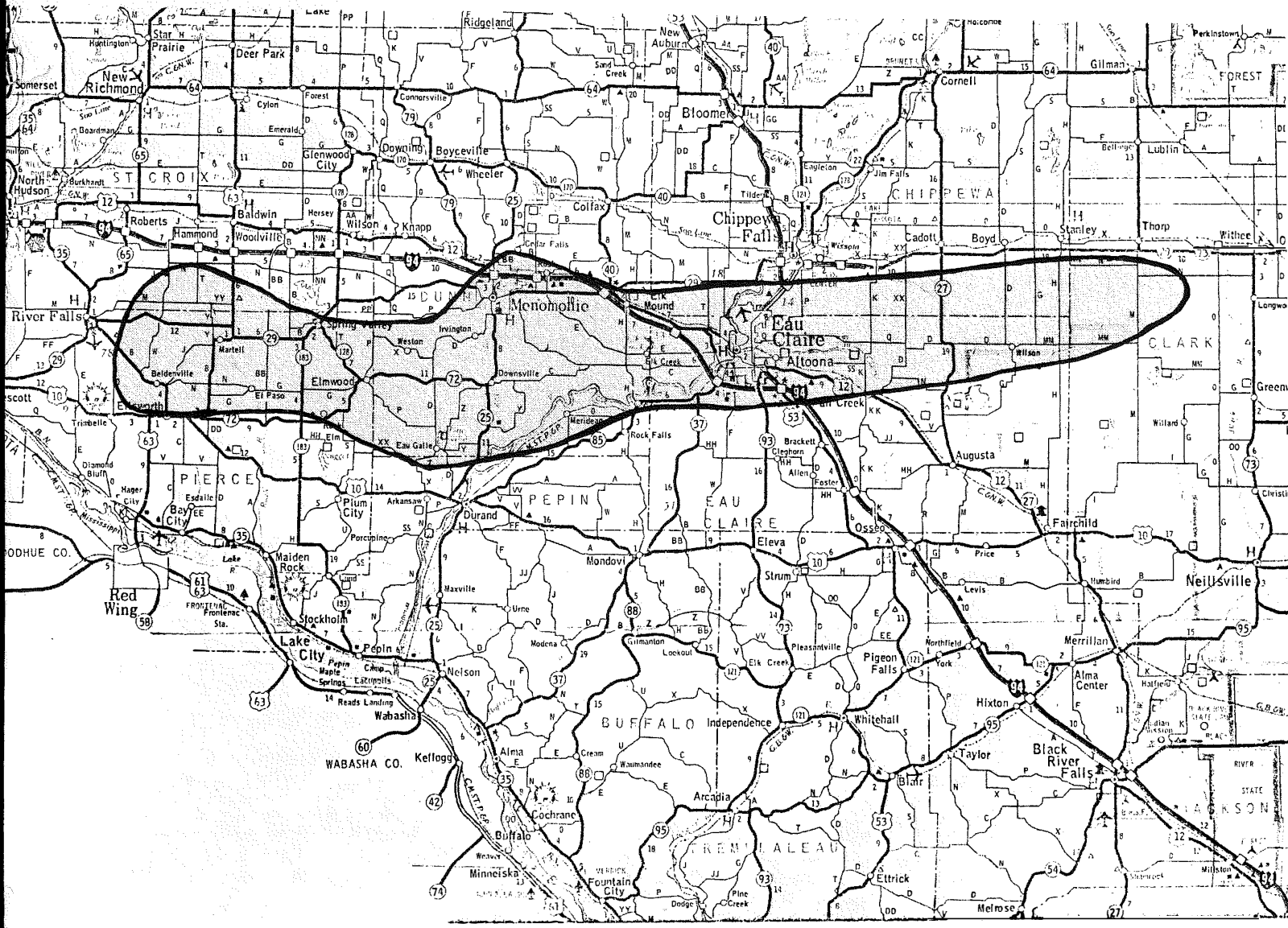

Figure 13. Area of Severe Wind Damage to Timber in West Central Wisconsin, 1980.

Late Spring Frost

Temperatures in Forest, Oneida, Florence, Marinette, Oconto and Vilas Counties dropped to below freezing several nights between June 9 and 17 killing new growth on white spruce and black ash.

Fall Cankerworm - *Alsophila pometaria* (Harris)

Numbers continued to decrease. Some light defoliation of soft maple and box elder occurred in Walworth, Jefferson and Waukesha counties. This may be the last gasp of an outbreak that began in 1975 and involved much of southern Wisconsin.

Gypsy Moth- *Lymantria dispar* (Linnaeus)

Intensive monitoring of known infestations and a state-wide detection survey by DNR, Wisc. Dept. Agr. and UDSA personnel continued this year. An infestation near Oconomowoc was detected in 1977 when 5 male moths were caught with racemic disparlure baited traps in a detection survey. In 1978, 643 males were caught with plus disparlure baited traps in an array of 16 per square mile. Eighty egg masses were found. In 1979, the area was treated with Gypcheck in May and with racemic disparlure in herculon plastic in July. No males were trapped inside the treated area; 4 were caught on the edges of the treated area with plus disparlure baited traps in an array of 16 per square mile. No egg masses were found. In 1980, the area was trapped with 32 plus disparlure baited traps per square mile. Twenty eight male moths were caught in what appears to be 3 small concentrations. Thirteen egg masses were found.

An infestation in Appleton, Wisconsin, was detected in 1975. The Appleton area has since been trapped with various arrays of traps and various forms of disparlure. The core area was trapped with plus disparlure in an array of 3 traps per acre in 1979 and again in 1980. In 1979, 7 males were caught; this year one was caught about 2 miles north of the original core area.

A statewide detection survey covered the areas shown in Figure 14. These areas were trapped with racemic disparlure-baited at one trap per 3 square miles excepting a few municipalities which were trapped more intensively.

State parks and state forest campgrounds were trapped with racemic disparlure-baited traps at a rate of 1 trap per 20 campsites. No male moths were caught.

Table 5 summarizes the trap catches for both the infestations and the detection survey.

Table 5. Gypsy moth trap catches in Wisconsin - 1980.

County	Municipality	Moths (No.)
Dane	Madison	4 (in scattered locations)
Outagamie	Appleton	1
Milwaukee	Milwaukee	2 (result of interception)
	River Hills	3
	Glendale	1
	Wauwatosa	1
	West Allis	1
Waukesha	Oconomowoc Lake	28
	Total	41

NURSERY PROBLEMS

Swat Team Progress Reports

In 1979, a Nursery Disease Control Swat Team was organized to determine the cause of stunting and mortality of conifers in Wisconsin Forest Tree Nurseries. The team is comprised of pathologists from the North Central Forest Experiment Station, and State and Private Forestry, U.S. Forest Service; DNR Pest Control, University of Wisconsin and DNR nursery managers. A work plan was developed for 1980 (Appendix A) and progress reports are presented in Appendices B-G.

Pine Seedlings Stunting and Root Rot - Unknown

Red and white pine seedlings, ranging in age from 1-0 to 3-0, again were affected by stunting and root rot at Griffith State Nursery, Wisconsin Rapids and Wilson State Nursery, Boscobel. Loss of white pine seedlings reached a high of 1,000,000 trees in 1979 at Griffith Nursery. The two problems were first obeserved in seedlings at the nurseries in 1978. The cause is unknown. Surveys are currently being made to determine presence of pathogenic fungi such as *Cylindrocadium* spp. and *Fusarium* spp. Nursery soil nematode populations are also being evaluated. (Appendix C)

Walnut Seed Rot - (Unknown)

Only 14% of the 700,000 black walnut seeds planted at Wilson State Nursery, in Boscobel, germinated this year. Usually between 40% and 50% of the seeds are viable. Bacteria in the genus *Erwinia* may be involved in the poor germination. It is suspected that they enter the shells through microscopic cracks and destroy the seed. Research on the prevention and control of the rot is in progress at the University of Wisconsin.

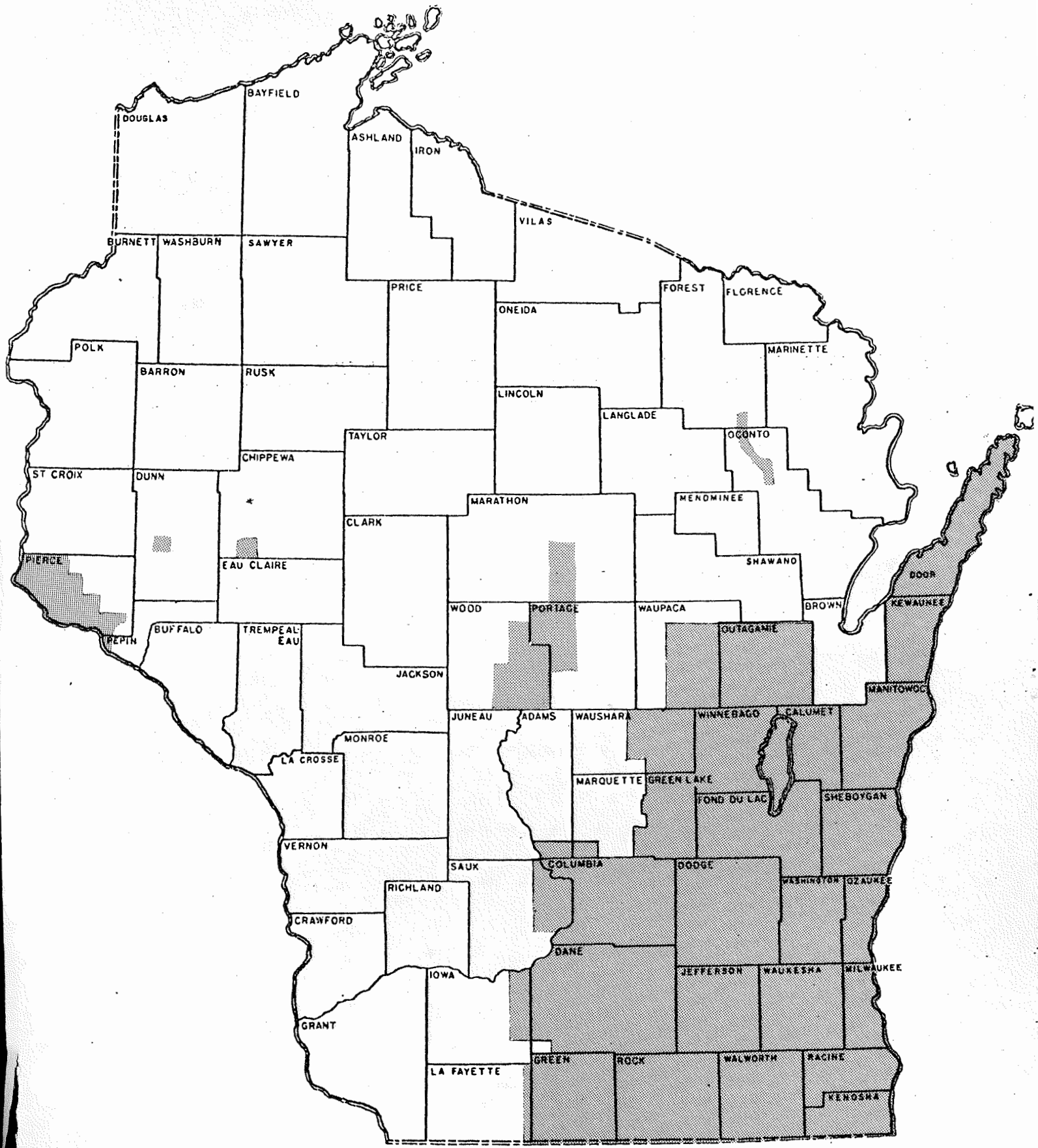

Figure 14. 1980 Gypsy Moth Detection Survey Area.

APPENDIX A

WISCONSIN NURSERY SWAT TEAM WORK PLAN

Nursery Disease Control Preliminary Work Plan
Wisconsin - 1980

Swat Team Action and Responsibilities

I. Soil and Foliar Analysis (Iyer, Prey and Zarnstorff[1]).

A. Collect soil and foliar samples from stunted red pine and white pine root rot areas at Griffith Nursery (Prey and Zarnstorff).

B. Conduct analysis of samples to determine the levels of nutrients in the soil and foliage (Iyer).

II. Enzyme Root Content (Iyer, Prey and Zarnstorff).

A. Collect samples from selected areas in each nursery (Prey and Zarnstorff).

B. Conduct analysis on enzyme root content to determine efficiency of root functions (Iyer).

III. Survey different cover crops for their influence on nematode and soil fungal populations, and nutrient cycling (Berbee[2], Prey, Zarnstorff, Iyer).

IV. Survey Soil for Nematodes, *Fusarium*, and *Clyindrocladium*

A. Collect soil and root samples and conduct laboratory work to determine the magnitude of the nematode population and potential for causing injury to conifer seedlings (Martin[3]).

B. Collect soil samples to check for the presence of *Fusarium* (Zarnstorff).

C. Collect soil samples to check for the presence of *Cylindrocladium* (Croghan[4]).

V. Continue to investigate the pathogenicity and epidemiology of *Fusarium oxysporum* (Berbee and Simmons[5]).

VI. Establish fungicide control plots for Diplodia shoot blight of red pine at Griffith and Wilson nurseries (Nicholls and Palmer[6]).

VII. Continue to investigate the cause of white pine root rot at Griffith Nursery (Nicholls and Palmer).

VIII. Investigate the effect of Mylone on certain soil fungi in vitro (Palmer).

IX. Investigate Mylone breakdown products and their effects on conifer seedlings (Prey, Zarnstorff and Devisetty[7]).

X. Investigate the cause of walnut seed rot at Wilson Nursery (Prey and Kuntz[8]).

[1] Lecturer, Department of Soil Science, University of Wisconsin-Madison; Forest Pathologist, and Laboratory Technician, Wisc. Dept. of Nat. Res.
[2] Professor of plant pathology, University of Wisconsin-Madison.
[3] Laboratory technician, Wisc. Dept. Nat. Res.
[4] Plant pathologist. USDA Forest Service, State and Private Forestry, St. Paul, MN.
[5] Graduate student, University of Wisconsin - Madison.
[6] Prinicipal and associate plant pathologist, USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN.
[7] Senior research scientist, Hopkins agricultural chemical company, Madison, Wisconsin.
[8] Professor of plant pathology, University of Wisconsin - Madison.

APPENDIX B

SOIL AND FOLIAR ANALYSIS OF STUNTED AND NONSTUNTED RED PINE.

by
Jaya Iyer and Jane Zarnstorff[1]/

On April 4, 1980, soil and foliage samples from stunted and nonstunted 1-0 red pine were collected for nutrient analysis from Block J, Section 72 at the Griffith State Forest Nursery, Wisconsin Rapids, Wisconsin. Eight soil and eight foliage samples were collected from stunted red pine. The same procedure was used for nonstunted red pine. A foliage sample consisted of the foliage from approximately fifty seedlings. Seven, six inch soil cores were collected from under the seedlings where the foliage samples were taken.

The foliage samples were analyzed by J.G. Iyer for the concentration of major nutrient elements and trace and accessory nutrient elements. Tables 1 and 2 give the averages for the eight samples. The soil samples were analyzed for the major nutrient elements, and averages of the eight samples are given in Table 3.

Results were interpreted by J.G. Iyer, who indicated that there was a low content of copper in both normally growing and depressed seedlings. The results of the foliage and soil analyses failed to indicate any significant influence of fertility factors. J.G. Iyer concluded that the depression of growth of red pine could have been due to unequal distribution or decomposition of applied eradicants. A complete summary of this report is on file at the Department of Natural Resources, forest pest management building, Madison, Wisconsin.

Table 1. Foliar concentration of Major nutrient elements in 1-year-old red pine. Griffith State Nursery, Wisconsin Rapids, Wisconsin.

	Average weights(g)			Foliar concentration(%)						
	Trees	Stems	Foliage	N	P	K	Ca	Mg	Na	S
Seedlings of normal growth	.38	.07	.31	1.56	.18	.61	.25	.10	.003	.12
Seedlings of depressed growth	.12	.02	.10	1.99	.19	.49	.34	.09	.003	.14

Table 2. Foliar concentration of trace and accessary nutrient elements in 1-year-old red pine. Griffith State Nursery, Wisconsin Rapids, Wisconsin.

	Avg. weights (g)			Foliar Concentration (parts per million)					
	Trees	Stems	Foliage	Al	Fe	Mn	B	Cu	Zn
Seedlings of normal growth	.38	.07	.31	810	635	495	15	3.3	105
Seedlings of depressed growth	.12	.02	.10	939	889	620	20	3.3	137

Table 3. Major fertility factors of soils supporting 1-year-old red pine seedlings of normal and depressed growth. Griffith State Nursery, Wisconsin Rapids, Wisconsin.

			Major nutrient elements				
	Reac.	Organic matter(%)	N (%)	P	K (ppm)	Ca	Mg
Seedlings of normal growth	5.0	2.4	.100	44	71	247	36
Seedlings of depressed growth	4.9	2.3	.098	47	77	237	31

[1]/Lecturer, Department of Soil Science, University of Wisconsin, Madison, and Latoratory Technician, Wisc. Dept. Nat. Res.

APPENDIX C

The Effects of Various Cover Crops and Fumigation on the Soil Populations of *Fusarium* spp., *Cylindrocladium* and Plant Parasitic Nematodes

by
Jane E. Zarnstorff and John G. Berbee[1/]

Introduction

Control of soil borne pathogens of conifer seedlings is one of the major goals of the Wisconsin state nursery swat team. Currently, soil fumigants such as methyl bromide and mylone are used in Wisconsin state forest nurseries to sterilize seed beds and decrease or eliminate populations of soil-borne Pathogens such as *Fusarium* spp., *Cylindrocladium floridanum* and *Rhizoctonia solani*. Soil fumigation has aided the nursery managers in producing disease-free seedlings, but its cost and the uncertainty of its long term effects on beneficial soil organisms has lead us to study alternative ways of providing a favorable soil environment for seedling growth.

The goals of this study were to:

1. Evaluate three cover crops, flax, buckwheat and sorghum-Sudan grass for their effects on populations of *Fusarium* spp., *C. floridanum* and plant parasitic nematodes.

2. Compare the effects of three treatments on controlling populations of *Fusarium* spp., *C. floridanum*, and plant parasitic nematodes in the soil.

The three treatments are:

1. Cover crop planted and soil fumigated with methyl bromide

2. Cover crop planted, no fumigation

3. Seed treatment with the fungicide Thiram 42-S in combination with each of the above treatments.

This project is a cooperative study between the Wisconsin Department of Natural Resources Forest Pest Control Unit and the University of Wisconsin, Department of Plant Pathology.

Materials and Methods

The cover crops chosen were flax, buckwheat and a sorghum-Sudan grass hybrid. Flax and sorghum-Sudan grass were chosen for their reported value in reducing populations of *C. floridanum* in the soil (Hadi, 1974). Buckwheat was used because of its current use in the Wisconsin state nurseries and its reported high production of organic matter by above ground plant parts (Hadi, 1974), The plots were established at Griffith Nursery, Wisconsin Rapids. They were arranged in a replicated randomized block design with four replicates for each treatment. Each plot was 7.6m by 18.3m and all together, the plots covered .486 ha. (2 nursery sections).

The previous history of these sections is as follows:

In 1979, these two sections contained maple, oak, cedar, norway and white spruce. After lifting, peat was applied. During 1980, sorghum-Sudan grass was planted in June, and plowed under in August. Rye was planted in August and plowed under in October. The sections were left fallow during the winter, and 12-5-28 fertilizer was applied on May 25, 1980, at the rate of 560.4 kilograms of product/ha. (.25 ton/acre).

The cover crops were machine planted on June 3, 1980. The check plots were left fallow. The soil was sampled for populations of *Fusarium* spp., *C. floridanum* and nematodes on June 9, 1980, before the cover crops had started growing, and on September 30, 1980, after the cover crops had been plowed under, and one half of the plots had been fumigated. Three rows of 10 soil cores (core=2cmx22cm) were collected per plot, equalling 30 cores per plot. Each row of 10 soil cores was combined, leaving 3 composite samples per plot. The samples were thoroughly mixed and 100 grams of soil from each sample was removed for *Fusarium* processing, and stored at 4°C. The rest of the samples were stored at 16°C. Each sample was processed for the number of *Fusarium* propagules by a dilution plate technique. The dilutions 1:10, 1:100, 1:500 and 1:1000 were used and potato dextrose agar supplemented with 500 ppm of the surfactant TMN (Banihashemi and DeZeeuw, 1969) was chosen for selective isolation of *Fusarium*.

[1/]Laboratory Technician, Wisconsin Department of Natural Resources and Professor of Plant Pathology, University of Wisconsin - Madison.

One composite sample from each plot was processed for the number of *C. floridanum* microsclerotia, and nematodes. The wet seiving technique and selective medium NPX (Theis and Patton, 1969), were used to isolate *Cylindrocladium* microsclerotia from the soil. The nematodes were extracted by wet seiving and separated from soil particles through the rapid centrifugal-flotation technique (Jenkins, 1964). Nematodes were fixed and stored in a solution of 6% glycerine and 4% formaldehyde.

Cylindrocladium and *Fusarium* plates were incubated at 20°C and observed 5-10 days after processing. The propagules of both fungi were counted and transferred to PDA slants for identification to species. C. floridanum isolates were identified by the shape of the vescicles (Sobers and Seymour, 1967). The total number of nematodes was counted in each sample, and a subsample of one ml of nematodes plus fixative was examined from each sample to estimate the number of parasitic and saprophytic nematodes. Permanent slides were made of the nematodes in the subsamples.

Observations of growth of the cover crops were taken in early July and flax was noted to have very poor germination and growth. The cover crops were plowed under on July 9, 1980. One half of the plots were fumigated with methyl bromide (MBC-33) at 336.2 kilograms product/ha. (300 lb/acre) on August 10, 1980. A second set of soil samples were collected on September 30, 1980, in the pattern described for the June sampling. The samples were processed by the same techniques.

In October, 1980, a study on the effectiveness of seed pelleting with the fungicide Thiram 42-S in controlling damping off was initiated in these two sections.

One-half of each section was seeded on October 6, 1980, to pelleted seed. One-half of the pelleted seed was red pine, one-half white pine. A sticker, Plyac, was applied to the seed at 95 ml/4.54 kilograms seed (.2 pint/10 lb) and the seed was pelleted with Thiram 42-S at 453.59 grams active/4.54 kilograms seed (1 lb/10 lb).

Results and Discussion

The average number of propagules of *Fusarium* spp. per gram of soil for each cover crop, is given in Table 1. The propagule counts were taken before the cover crops started growing (June 9, 1980) and again after they were plowed under and one half of the plots had been fumigated with methyl bromide (MBC-33 at 336.2 kilograms product/ha., September 30, 1980).

An analysis of variance of the propagule populations on June 1, 1980, showed a significant difference (.01 level) between populations in plots to be fumigated and plots not to be fumigated. The plots which were not to be fumigated had significantly higher populations than the plots to be fumigated.

These differences cannot be linked to the treatments since no treatments had been applied by the time of the first sampling. However, this significant difference does show the high variation in populations of *Fusarium* that may exist between two nursery sections that have received the same treatments for two years.

All populations of *Fusarium* were reduced to zero in the fumigated plots. In the nonfumigated plots, the populations increased and decreased randomly and there were no significant differences found between the propagule numbers in the different cover crop or check plots.

Table 2 gives the populations of nematodes at the two sampling dates. Nematode populations were reduced in every fumigated plot. Subsampling of the nematode populations revealed no parasitic nematodes at either sampling date, only saprophytic nematodes were observed.

Table 3 gives the number of microsclerotia of *C. floridanum* per gram of soil from the September sampling. Data from the June sampling was considered invalid due to difficulties with the selective medium. All of the fumigated plots had microsclerotia populations of zero in the October 1 samples. Previous work (Hadi, 1974) indicates that under optimum conditions for disease development, 1 propagule per gram of soil is enough to result in considerable *Cylindrocladium* root rot. One or more propagules per gram of soil were found in 18.75% of the plots sampled in October.

The data from Table 1 indicates that none of the cover crops had any effect on reducing the populations of *Fusarium* propagules. The flax germination and growth was very poor and there were very few above ground plant parts for incorporation into the soil. The seeder had to pass several times over all the plots to complete seeding, and the compaction from the seeder may have impaired germination of the flax. Also, Hadi, 1974, suggests that the planting and incorporation of cover crops twice during the growing season may be necessary to produce the amount of organic matter needed for increasing microbial activity and competition between the soil pathogens and other soil fungi and bacteria for nutrients. The amount of organic matter produced by the crops in this study may not have been enough to effect the pathogen population significantly.

All of the subsamples revealed no parasitic nematodes, and soil sampling throughout the nursery during 1980 revealed the same results. Therefore, nematodes are currently not considered a problem in causing disease in conifer seedlings in the Wisconsin state nurseries. Subsequent sampling of seedling roots for nematodes will be done during the 1981 growing season.

C. floridanum is still present in the nursery as indicated by the populations in the nonfumigated area and should not be discounted as a possible source of root rot.

Fumigation with methyl bromide was effective in reducing all populations of *Cylindrocladium* and *Fusarium* to zero. But because of the problems stated earlier with fumigation, and recontamination of sterile beds, more work is needed to find alternative ways to alter the soil environment and make it unfavorable for growth of these pathogens.

Work in the cover crops plots will continue in 1981 with a survey for plant parasitic nematodes in the roots of seedlings and an evaluation of the effectiveness of seed pelleting with Thiram 42-S.

Table 1. Propagules of *Fusarium* spp. per gram of soil in June and September, 1980, from plots where three cover crops were grown at Griffith State Nursery, Wisconsin Rapids, Wisconsin.

	Avg. No. of Propagules Per Gram of Soil			
		Section H-95	Section H-96	
Cover Crop	June	September (Fumigated)[1]	June	September[2]
Flax	990	0	1,495	2,415
Sorghum-Sudan	1,101	0	3,226	1,952
Buckwheat	1,351	0	2,306	2,078
Check	855	0	2,160	2,698

[1]Fumigated with MBC-33 @ 336.2 kilogram product/ha, August 10, 1980.
[2]Not fumigated.

Table 2. Number of nematodes per 100 grams of soil in June and September, 1980, from plots where three cover crops were grown at Griffith State Nursery, Wisconsin Rapids, Wisconsin.

	Nematodes per 100 grams of soil			
		Section H-95	Section H-96	
Cover Crop	June	September (fumigated)[1]	June	September[2]
Flax	344	1	260	108
Sorghum-Sudan	342	0	202	175
Buckwheat	285	1	213	108
Check	278	0	217	73

[1]Fumigated with MBC-33 @ 336.2 kilograms product/ha, August 10, 1980.
[2]Not fumigated.

Table 3. Propagules of *Cylindrocladium floridanum* per gram of soil in September, 1980, from plots where three cover crops were grown at Griffith State Nursery, Wisconsin Rapids, Wisconsin.

	Propagules per gram of soil	
	Section H-95	Section H-96
Cover Crop	September (fumigated)[1]	September[2]
Flax	0	1.6
Sorghum-Sudan	0	.4
Buckwheat	0	.64
Check	0	.2

[1]Fumigated with MBC-33 @ 336.2 kilograms product/ha, August 10, 1980.
[2]Non fumigated.

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APPENDIX D

Evaluation of Pathogenic Levels of *Cylindrocladium* and *Fusarium* in Two State Nurseries in Wisconsin

by
Catherine F. Croghan[1/]

Introduction

Extensive death of white pine (*Pinus strobus* L.) in two Wisconsin state nurseries, Griffith and Wilson, prompted this evaluation. The losses were observed initially at Griffith in 2-0 beds during the 1979 growing season, and at Wilson in beds of seedlings of similar age during the 1980 season.

USDA Forest Service personnel, working cooperatively with the Wisconsin Department of Natural Resources, concluded that the mortality was caused by a root decay pathogen. Palmer and Nicholls (1980) isolated *Cylindrocladium* from the roots of diseased Griffith seedlings. Earlier, Thies (1969) documented a history of this root rot pathogen in the nursery. On the basis of this information, it was decided that a quantitative survey of *Cylindrocladium* soil propagules was needed.

It appeared that the same fungus might be the cause of the decay seen at both nurseries since the development of symptoms was similar. Therefore, soils at both nurseries were screened for *Cylindrocladium* propagules. Soils at Wilson Nursery also were screened for species of *Fusarium*.

This evaluation was designed to determine if the severity of white pine root decay was correlated with populations of *Cylindrocladium* and *Fusarium* in the soil.

Materials and Methods

Soil samples were collected in Griffith Section B-11, K-4 and A-7, and in Wilson Section B-46 and 47. Each sample was a composite of 5, 6-inch cores collected with a 1-inch auger. The samples were kept cool in the field and later stored in the lab for one week at 5°C prior to propagule analysis.

All 5 sections contained or had recently contained white pine seedlings (Table 1). In 1980, approximately 50 percent of the seedlings in section B-11 were infected. Trees in section K-4 had shown damage (25 percent in 1979), but appeared to be recovering in 1980. Both of these sections had been fumigated with mylone before planting. A-7 had not been fumigated for several years, and there was no toot rot in white pine grown in this section and lifted in 1980. Therefore, A-7 was used to determine background levels of *Cylindrocladium* in Griffith Nursery. Before planting, Wilson Nursery sections B-46 and B-47 were fumigated with mylone (Dowfume) and methyl bromide (MC-33). In 1980, 2-0 white pine seedlings planted in B-46 showed damage similar to that observed at Griffith, while those in adjacent section B-47 appeared healthy.

A dilution plate technique was used to isolate *Cylindrocladium* from the soil. For each sample, 20 g (fresh weight) of soil was suspended in 200 ml of 0.3 percnet water agar. One ml of this 1:10 dilution was planted on sucrose lima bean agar (SLBA) in triplicate (Hunter and Barnett 1978). Serial transfers were made from the 1:10 soil suspension to sterile water blanks, resulting in 1:100 and 1:1000 dilutions. One ml of each of these dilutions was planted in SLBA in triplicate. All dilution plates were incubated in the dark at 23°C for one week before screening for *Cylindrocladium* colonies. Sample colonies were transformed to pure culture for positive identification. The number of propagules/g of air-dried soil was calculated following adjustments for moisture content of the samples.

Section B-46 and 47 soil samples also were also analyzed for the presence of *Fusarium* species. The methods were identical to those outlined; however, pentachloronitrobenzene (PCNB) plates (Nash and Snyder 1962) were used to determine the presence of *Fusarium* at 1:10, 1:500 and 1:1000 dilutions.

Results

Cylindrocladium sp. was recovered from all of the Griffith Nursery sections examined. *Cylindrocladium* population levels in the recovered section, K-4 were similar to those found for the check, A-7 (Table 1). Section B-11, where symptoms were most severe, had levels much higher than the other two.

No *Cylindrocladium* was recovered from the initial samples at Wilson Nursery (Table 1). To confirm these findings and screen for other potential root pathogens, a second set of samples was examined. No *Cylindrocladium* spp. were found; however, *F. solani* (Mart.) App. & Wr. Snyd. & Hans. was recovered from the mylone-treated section, B-46 em. (Table 2). Although the propagule counts were relatively high, only 7 percent of the B-46 samples had colonies of this fungus.

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Table 1. Results of soil dilution analysis to determine presence or absence of *Cylindrocladium* spp. at Wilson and Griffith State Nurseries.

Nursery	Plot location	Fumigant	Symptom expression	No. samples examined	Precent samples with colonies	No. Progagules/g of soil
Griffith	B-11	Mylone	Present	27	48	58
Griffith	K-4	Mylone	Recovered	24	29	17
Griffith	A-7	None	Absent	4	25	15
Wilson	B-46	Mylone	Present	15	0	0
Wilson	B-47	MC-33	Absent	15	0	0

Table 2. Results of soil dilution analysis to determine presence or absence of *Cylindrocladium* spp. and *Fusarium* spp. at Wilson State Nursery.

Fungus	Plot location	Fumigant	Symptom expression	No. samples examined	Percent samples with colonies	No. Propagules/g of soil
spp.	B-46	Mylone	Present	20	0	0
spp.	B-47	MC-33	Absent	10	0	0
	B-46	Mylone	Present	20	7	5020
	B-47	MC-23	Absent	10	0	0

Discussion

The number of *Cylindrocladium* propagules that constitute a threshold for damage to pine seedlings is not well established. The literature suggest 8-10 propagules/g of soil (Thies 1969). However, these counts are based on only one type of propagule, the microsclerotium. Our evaluation covers all possible propagule types (conidia and hyphal fragements as well as microsclerotia). Therefore, we expect the threshold for our evaluation method to be higher than the one outlined previously.

The values of 15 and 17 propagules/g of soil for A-7 and K-4, respectively, appear to represent the background level at Griffith. Neither of these sections was severely damaged with root rot. However, the elevated populations, 58 propagules/g of soil, in B-11 was associated with severe root decay.

An examination of the fumigation history of section B-11 points to a possible reason for the elevated levels of *Cylindrocladium*. A sorgum sudan cover crop was grown in B-11 before fimigation. Due to a labor dispute, the cover crop was allowed to attain a height of approximately 5 feet. This large size made it difficult to turn the soil and resulted in large clumps, which leads to incomplete fumigation. *Cylindrocladium* species are known to be poor competitors and tend to do well only when other soil microorganisms are limited. Incomplete fumigation would present an ideal environment for the expection of populations of *Cylindrocladium* species that remain.

The results of the screening for *Fusarium* did not identify the cause of white pine root decay at Wilson Nursery. Although, *F. solani* was recovered from the beds at high rates, there are no confirmed reports of this fungus as a pathogen of conifers. *F. solani* has been found in association with decaying root tissue (Pawuk 1978; Pawuk and Barnette 1974, Vaartaja and Bumbieris 1967), but it remains unclear whether the fungus acts as a primary or secondary pathogen or as a saprophyte.

Conclusions

1. The result of this evaluation, when considered with the findings of Palmer and Nicholls (1980), suggest that a *Cylindrocladium* species is the cause of the white pine root rot at Griffith Nursery.

2. High populations of *Cylindrocladium* probably developed as a result of incomplete soil fumigation.

3. Although *Fusarium solani* was recovered, the cause of the white pine root decay at Wilson State Nursery has not been determined.

Recommendations

When soil fumigants are applied, care should be taken to follow label recommendations for prefumigation soil preparation. Application rates should be followed strictly to ensure consistent results.

Pesticide Precautionary Statement

The pesticides reported on and recommended here were registerd for the use described at the time this manuscript was prepared. Since the resgistration of pesticides is under constant review by State and Federal authorities, a responsible State agency should be consulted as to the current status of this pesticide.

Pesticides can be injuroius to humans, domestic animals, desirable plants and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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APPENDIX E

DIPLODIA PINEA IN NURSERY SEEDBEDS

by
Thomas H. Nicholls, Marquerita A. Palmer and Michael E. Ostry[1/]

The Problem:

The fungus *D. pinea* has been found to cause shoot blight or death of red pine seedlings at Wilson, Griffith, and Hayward State Nurseries in Wisconsin; and Eveleth Federal Nursery and General Andrews State Nursery in Minnesota. In 1980 the fungus was found on both red and jack pine seedlings at Toumey Federal Nursery, Michigan.

D. pinea can be a serious nursery pathogen. In untreated 10' x 4' plots of our 1979 fungicide tests on 3-0 red pine at Griffith Nursery, infection levels were as high as 19%. At Wilson Nursery, initial infection in several spray plots was 50-60%. However, infection levels vary from year to year and from area to area within nurseries. In 1980, due to a dry spring, very few new infections were observed on 2-0 and 3-0 red pine in our study areas. Still, numerous infected 1-0 seedlings were noted at Griffith and Wilson Nurseries.

Objectives:

The objectives of our *Diplodia* research for 1980 were to continue testing fungicides for control of *D. pinea* in Lake States nurseries.

1980 Result

Diplodia spore dispersal:

Since 1976, when *D. pinea* was first determined to be an important pathogen in the Lake States, spore dispersal data have been collected in order to understand the life cycle of the organism. Identification of spore release and infection periods is necessary to determine when fungicide sprays should be applied. Peak spore production by the fungus usually coincides with shoot elongation of the conifer host. This is when host tissue is most susceptible to infection. To monitor *D. pinea* spore dispersal patterns, vaseline-coated microscope slides were exposed at weekly intervals in several nurseries and plantations in Minnesota, Wisconsin and Iowa.

During the past 4 years, *Diplodia* spore dispersal patterns have been characterized at Griffith Nursery. In 1980, data were also collected at Wilson Nursery. *D. pinea* spore dispersal patterns for 1980 are shown for these nurseries in Figures 1 and 2. *Diplodia* spores are rainsplash disseminated, so large amounts of spores were collected only during periods of rainfall. The peak period of spore dispersal did not occur at Wilson Nursery until July, while Griffith Nursery it occurred in late May as in previous years. Late initiation of spore dispersal at Wilson Nursery was probably due to the limited amount of spring rainfall in this area.

Yearly spore dispersal data collected in Minnesota, Wisconsin and Iowa for the 5-year period, beginning in 1976, was combined to provide control guidelines for Lake States nurseries. Figure 3 indicates the critical fungicide protection period needed for nursery seedlings.

Fungicide Tests

Results from 1979 fungicide tests indicated that benomyl gave good control, but the first spray may have been applied a week late expaining why complete control was not achieved. This year, an attempt was made to spray plots at an earlier stage of host development and the fungicide tests were redesigned to provide information on the number of sprays needed to achieve control.

Fungicide spray test plots were established at two locations in 2-0 red pine seedbeds at both Griffith and Wilson State Nurseries, Wisconsin. Two fungicides, benomyl and chlorothalonil, were tested. A randomized block experimental design was used. Treatments and results are presented in Tables 1 and 2.

Analysis of spray results revealed no significant differences among nine treatments at either location. This is due to the overall low amount of infection that occured in 1980. Lack of infection was probably due to the low amount of inoculum produced and, in the case of Wilson Nursery, late spore production at a time when seedlings were not susceptible. Although 1980 test results were not satistically significant, there was some indication that benomyl was more effective than chlorothalonil in controlling the disease as it was in 1979. Laboratory tests proved this conclusively (see Progress Report No. 1).

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Conclusion

In Lake States nurseries, 2-0 and 3-0 red pine seedlings should be protected by 4-5 fungicide sprays applied at 2-week intervals from May to mid-July. The control period for 1-0 seedlings is not known. Benomyl gives better *Diplodia* control than chlorothalonil. However, further testing of benomyl will be required to obtain the necessary data needed for EPA registration. Chlorothalonil is being dropped from our tests because it does not provide effective control.

Plans for 1981

1. Additional fungicides will be tested in laboratory petri dish tests for activity agains *D. pinea*. Chemicals that show promise will be field-tested in 1981.

2. The susceptible period for 1-0 seedlings appears to be somewhat different than for 2-0 and 3-0 seedlings. For example, 1-0 seedlings at both study areas were infected, when older seedlings were not. In 1981 we will attempt to discover the length of time when 1-0 seedlings should be protected from *D. pinea* infection.

3. We will continue studies of the biology of *D. pinea* and other methods for control.

Table 1. Results of 1980 fungicide sprays for *D. pinea* on 2-0 red pine seedlings at Griffith Nursery, Wisconsin.

Number of sprays*	Chemical	% active ingredient	Trees infected (Average of four plots)[f]	
			Location 1	Location 2
0[a]	Unsprayed	0	37.3	14.0
1[b]	Benomyl	0.3[g]	8.8	2.3
2[c]	Benomyl	0.3	3.5	1.5
3[d]	Benomyl	0.3	2.8	0.8
4[e]	Benomyl	0.3	2.8	0.8
0[a]	Unsprayed	0	30.0	11.3
1[b]	Chlorothalonil	0.45[h]	35.0	13.0
2[c]	Chlorothalonil	0.45	6.8	7.5
3[d]	Chlorothalonil	0.45	18.3	5.0
4[e]	Chlorothalonil	0.45	5.8	6.0

*Spray dates: a/ no treatment
b/ 5/6/80
c/ 5/6/80; 5/20/80
d/ 5/6/80; 5/20/80; 6/3/80
e/ 5/6/80; 5/20/80; 6/3/80; 6/18/80
f/ 1900 trees per plot.
g/ 0.3% active ingredient is equivalent to 5 lbs. commercial product per 100 gallons of water for a fungicide with 50% active ingredients.
h/ 0.45% active ingredient is equivalent to 9.28 lbs. commercial product per 100 gallons of water for a fungicide with 40.4% active ingredients.

Table 2. Results of 1980 fungicide sprays for *D. pinea* on 2-0 red pine seedlings at Wilson Nursery, Wisconsin.

Number of sprays*	Chemical	% active ingredient	Trees infected (Average of four plots)[f]	
			Location 1	Location 2
0	Unsprayed	0	43.5	45.3
1[a]	Benomyl	0.3[g]	20.5	21.3
2[b]	Benomyl	0.3	6.5	23.0
3[c]	Benomyl	0.3	18.3	8.5
4[d]	Benomyl	0.3	13.0	6.5
0[a]	Unsprayed	0	50.0	35.5
1[b]	Chlorothalonil	0.45[h]	45.8	25.5
2[c]	Chlorothalonil	0.45	70.3	44.0
3[d]	Chlorothalonil	0.45	36.0	26.5
4[e]	Chlorothalonil	0.45	44.5	32.5

*Spray dates: a/ no treatment
b/ 5/5/80
c/ 5/5/80; 5/19/80
d/ 5/5/80; 5/19/80; 6/2/80
e/ 5/5/80; 5/19/80; 6/2/80; 6/17/80
f/ 1400 trees per plot
g/ 0.3% active ingredient is equivalent to 5 lbs. commercial product per 100 gallons of wter for a fungicide with 50% active ingredients.
h/ 0.45% active ingredient is equivalent to 9.28 lbs. commercial product per 100 gallons of water for a fungicide with 40.4% active ingredients.

APPENDIX F

Progress Report of Work Completed During the 1980, Field Season Concerning White Pine Root Rot at Griffith and Wilson State Nurseries.

by
Marguerita A. Palmer and Thomas H. Nicholls[1/]

The Problem

Root rot from an unknown cause has caused serious losses in white pine at Griffith and Wilson State nurseries in Wisconsin in recent years. In 1980, root rot continued to be a problem in Section B-11 at Griffith and in Sections B-46 and B-47 at Wilson Nursery. To date at Griffith Nursery, 1,000,000 white pine have been lost (Wisconsin DNR Forest Pest Situation Report issued October 21, 1980). Root rot was most severe in mylone-treated beds, but some damage also occurred in scattered areas of methyl bromide-treated beds.

Objective

Our objective was to try to identify the cause of the problem by monitoring and isolating from infected white pine.

1980 Results

Seedling mortality:

Seedling mortality was monitored at each nursery using 10 plots, each 1 m. in length, located randomly in affected areas. The number of healthy seedlings per plot was recorded at each visit. Plots were maintained throughout the growing season at Wilson Nursery, however, at Griffith Nursery, stakes marking the plots were removed during root pruning operations, and thus, data were lost as a result. At Wilson Nursery, the greatest mortality occurred between June 3 and June 20, 1980, (Figure 1). Initially, there was a combined total of 640 healthy seedlings. By September 23, only 480 healthy seedlings remained for a 25 percent mortality rate during the monitoring period.

Seedling isolations:

This year, recovery of the fungus *Cylindrocladium* from diseased seedlings was emphasized. Eight collections were made of seedlings from the problem areas at both nurseries. Seedlings were examined and isolations made from diseased tissue. Isolations from the first four samples collected (4/22, 5/8, 5/20, 6/4) were made using three media each selective for different fungi (PCNB, Czapeks and Corn Meal Agar). A fourth medium, (Potato Dextrose agar) used was non-selective. About mid-June, in conversations with Dr. Barry Hunter, California State University, California, Pennsylvania, who is working on the taxomony of *Cylindrocladium* we learned of a new selective medium, (glucose-lima bean) for *Cylindrocladium*. Isolations made June 18 and afterwards used a modification of this medium.

Cylindrocladium was recovered from 20 percent of the infected trees in the early part of the growing season at both nurseries (Figure 1 & 2). Although this is not a high percentage of trees, it is considered a highly significant result for white pine (Barry Hunter, personnel communication) because it is more difficult to isolate *Cylindrocladium* from white pine that it is from other species, such as white spruce and red pine. Other researchers have found it difficult to isolate the fungus from white pine seedlings including those that had died in soil inoculated with pure cultures of *Cylindrocladium*, (Anderson and Anderson 1963).

Catherine F. Croghan, S&PF Pathologist, recovered 58 *Cylindrocladium* propagules/g soil in B-11 Griffith Nursery (Croghan 1981). This level of inoculum is considered to be high enough to cause serious root rot in nursery beds. These results, along with ours, suggest *Cylindrocladium* as a major cause of white pine root rot at Griffith Nursery.

Although we recovered *Cylindrocladium* from white pine roots at Wilson Nursery, Croghan did not recover any from the soil. This difference in recovery may be explained by several factors, the most important of which is time of year. Thies (1968) and Griffin et al. (1978) report increased soil temperatures to have a negative effect on *Cylindrocladium* populations. Although present, the fungus is more difficult to obtain from soil and plant tissue with increasing seasonal temperatures. This is what could have happened in our studies. Soil samples may have been taken too late from Wilson Nursery to recover the fungus. To be absolutely sure that *Cylindrocladium* is the pathogen at Wilson Nursery, the soil must be sampled when the fungus is active (apparently in May at Wilson Nursery) to provide the final evidence. This will be done in 1981.

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Geranium baiting:

Geranium baiting, a technique to determine qualitatively the presence of *Cylindrocladium* in the soil, was initiated on June 18. Soil samples were collected from problem areas at both nurseries. Geranium leaves were inserted into the soil and observed for the development of *Cylindrocladium* on the leaves. The fungus was recovered from soil using this technique (Tables I & II). We noticed a serious outbreak of *Cylindrocladium* in a mylone-treated bed of white spruce in K-4, Griffith Nursery on November 5, 1980. Four soil samples were taken from various parts of the unit, *Cylindrocladium* was recovered from all four samples as well as from tree isolations.

Other fungi:

Fungi other than *Cylindrocladium* were recovered during isolations from trees such a *Penicillium* and *Alternaria*, but they are presumably not pathogenic. No new fungal species were found this year that were not found last year.

Summary

Recovery of *Cylindrocladium* from diseased root tissue was greatest in early spring; recovery declined starting in July. Isolations from Griffith Nursery show increased recovery using glucose-lima bean agar. *Cylindrocladium* was not consistently recovered from all areas where diseased trees were present using the geranium baiting technique. However, this technique was not initiated until June 18, after which there was a decline in recovery of the fungus from isolations of diseased tissue.

Conclusion

Cylindrocladium is playing a key role in the white pine root rot problem at both nurseries. This conclusion is based on its recovery from diseased tissue and from soil using soil dilution (except Wilson Nursery) and geranium baiting techniquies. It is evident that mylone, as it has been used, is not effectively controlling this pathogen. Though some results are not completely conclusive, they have certainly given a clear signal as to the probable cause of the white pine mortality. There may still be other unidentified predisposing factors (e.g. growing certain cover crops or applying high nitrogen fertilizer stimulating *Cylindrocladium* growth) that may be contributing to the problem. Cultural, chemical, or pathogenic factors may also contribute to root tissue damage of white pine. However, we know *Cylindrocladium* is present in both nurseries and that historically is has been a seroius root disease pathogen in Wisconsin nurseries. Therefore, chances are excellent that it will periodically continue to give us problems, particularly if mylone is used as a control. Other chemical, cultural and biological controls are needed.

Plans for 1981

We will be reducing our efforts on the white pine root root problem in 1981. However, we plan to follow up on these items.

1. We plan to do serological testing of white and red pine and white spruce isolates to determine if there are different strains of *Cylindrocladium* in the nurseries. This may help explain differences in host susceptibility and control of the fungus.

2. We plan to isolate from white pine in B-46 and B-47 at Wilson Nursery at the best time (May) of the year to recover the fungus. We will also assist Al Prey's group with soil dilution recovery methods to be done at the same time. This should provide us with the conclusive evidence that we need at this nursery.

3. Along with other S.W.A.T. team members, we will closely monitor Unit G at Griffith Nursery where beds with mylone and methyl bromide-treated soil and untreated soil were established to study the development of the white pine root rot under these three treatments.

4. We are also working on a how to leaflet: "How to identify and control *Cylindrocladium* root rot of conifers."

Acknowledgements

We would like to thank Ken Wojhan, Dick Camp and John Borkenhagen, Wisconsin Department of Natural Resources and other S.W.A.T. team members for their excellent cooperation during all of our efforts to bring the white pine root rot problem to a satisfactory conclusion.

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Table 1. Recovery of *Cylindrocladium* from geranium baiting. Griffith Nursery Soil, Sec. B11.

Date	Soil samples	recovery
	Number	Percent
6/28	27	11.1
7/10	25	24.0
8/5	30	6.7
11/5	20	0

Table II. Recovery of *Cylindrocladium* from geranium baiting. Wilson Nursery soil.

Date	Location	Soil samples	recovery
6/28	B46[1/]	15	6.7
	B47[2/]	15	6.7
7/10	B46	30	6.7
	B47	10	0
8/5	B46	30	0
	B47	10	0
9/23	B46	20	5
	B47	10	0

1/ B46 = mylone fumigated.
2/ B47 = Methyl bromide fumigated.

APPENDIX G

Soft Rot of Walnut Seed

by
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Black walnut (*Juglans nigra* L.) is a valuable hardwood in eastern and central United States, prized both for the flavor of its nuts (Zarger 1969) and for the beauty of its wood (Blyth 1973; Clark 1969a). In recent years, its culture and managment have been studied and clarified (Clark 1969b), facilitating the establishment of numerous plantations in the Central States (Burke and Williams 1969; Schlesinger and Funk 1977). To meet the increasing demand for planting stock, forest nurseries have expanded their seedling production (Brinkman 1974). In Wisconsin, the Wilson State Forest Nursery at Boscobel produces annually approximately 300,000 one-year-old walnut seedlings for planting in southern Wisconsin. According to Richard Camp, nursery manager, demand for planting stock always exceeds nursery production. A newly recognized disease, bacterial soft rot of walnut seed, limits seedlings production. In this report, the symptoms of the disease are described. In addition, research progress is discussed inculding identification of the bacterial agent or agents causing the disease and the manner of transmisison of the bacterial pathogens.

Seedling Production and Disease Losses

Each fall the nursery obtains walnut seed from a variety of sources, but most is collected locally. Husks are removed by running the nuts through a mechanical dehusker, a metal drum fitted with spinning rubber paddles. In this process, some of the nuts are cracked to varying degrees. The dehusked nuts are planted immediately in seedbeds previously fumigated with methyl bromide. To insure a satisfactory stand, the walnut seeds are planted closely (12 to 15 nuts per linear foot) in furrows approximately four inches in depth. The nuts stratify in the seedbed overwinter and germinate the following spring. Seedlings grow for one summer season and are sold the next spring.

In the fall of 1979, 700,000 walnuts were planted at the Boscobel Nursery. At "normal" germination rates of 50 percent, this planting should have produced a crop of 350,000 seedlings. However, average germination in the seed beds was about 20 percent due primarily to soft rotting of the ungerminated seed. Therefore, because of this disease, fewer than 150,000 seedlings will be available for outplanting in 1981. Presently, walnut seedlings sell for $.11 a piece. The difference between expected crop (350,000) and the actual crop (less than 150,000) represents a loss of over $22,000, not including production costs.

Symptoms and Etiology of Seed Rot

Repeated examination of different walnut seed lots sown in 1979 indicated that poor germination resulted mainly from soft rot of the kernels. Symptoms ranged from a "cheesy" to "mushy" to "soupy" breakdown of coytyledons inside the shell. Macerated tissue was not discolored.

Several species of bacteria in the genera *Pseudomonas* and *Erwinia* have been isolated from rotted nuts collected in 1978, 1979 and 1980. Inoculations of walnut kernels with individual isolates resulted in softening to the "mushy" symptoms, but none progress to the "soup" symptoms. In present studies, whole nuts are inoculated not only with single bacterial isolates but also with different combinations of isolates to determine if "soupy" symptoms can be reproduced. If more than one species of bacteria are shown in to responsible for disease, possible successional or synergistic interactions among them will be studied.

Epidemiology of Soft Rot

Isolations were made from developing walnuts during the summer of 1980. In general, the kernels of seed picked from different walnut trees were free of bacteria and fungi through August 1, and confirming Kessler's recent findings (personal communication; Kessler 1979). Many nuts collected in September, however, we contaminated and a small percentage were already "soupy". The egg-laying period of the walnut husk fly (*Rhagoletis suavis*) and the initial stages of husk decomposition preceed and overlap the first observation of soft rot in nuts in September. Research is in progress to determine if the husk fly and its magot are associated with bacterial soft rot.

Walnut shells are permeable to water. Experiments have demonstrated that solutions of methyl red dye can enter natural cracks or openings in the shell of hand-husked nuts and stain the interior within 12 hours. Thus, fluids from decomposing husks on walnuts could provide an ideal means for inital infestation of the walnut seed with bacteria. Once the exact agent or agents of the disease are known, isolations will be made from walnut husk flies and husks to determine if they are infested with the specific bacterial pathogens.

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Mechanical husking also may provide optimal conditions for inoculating the walnut seeds since during husking, the husks are pulverized, and the nuts are tossed, mixed and sometimes cracked. However, in field trials, germination rates and soft rot incidence for husked and nonhusked walnuts did not differ significantly.

In 1980 there was a large variation in germination rates among different seedbeds (2 percent to 37 percent). These differences may be due to seed source, local concentration of soilborne pathogens. Greenhouse and nursery studies are in progress to determine the effect of these variables of soft rot development. Other variables under investigation are storage and seedbed conditions and different methods of husk removal.

Summary

Soft rot of black walnut seed (*Juglans nigra* L.) is a previously unreported disease. Symptoms range from a "cheesy" to "soupy" breakdown of the kernel. Macerated tissues are not discolored. Bacteria from the genera *Pseudomonas* and *Erwinia* have been isolated from diseased nuts, but it is not yet known whether one species acts alone to incite the disease, or if different species act in succession or in a synergistic complex to produce disease symptoms. Because the disease agents are not found in kernels prior to August, the pathogens probably are not transmitted from tree to seed. However, soft rotted nuts were found on trees as early as September indicating the causal agent(s) can be transmitted to seed still on the tree. Studies are in progress to determine how the bacteria are transmitted to the seed and how they enter the kernel.

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